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FRACTURES AND SEPARATED EPIPHYSES

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AND

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BY

ALBERT J. WALTON
F.R.C.S. (Eng.), M.S. (Lond.), L.R.C.P., M.B., B.Sc. (Lond.)
SURGICAL REGISTRAR, LONDON HOSPITAL

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TO

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PREFACE

STUDENTS and those first commencing hospital appointments have often mentioned to me their need of a small book dealing with the more practical aspect of fractures. This book is an attempt to supply such a want. I have aimed throughout at giving special attention to the smaller details of treatment, such as applying the different forms of splint, so that anyone having no special previous knowledge of this branch of surgery might find this book an aid to him in the practical treatment of any fracture. At the same time it has been thought advisable to describe in their main outlines the more complex methods, including open operation, which may at times be necessary.

As far as possible the prognosis has been dealt with, in the hope that some help may thereby be given in those cases, so commonly met with nowadays, which involve seeking compensation in the County Courts, for upon such cases it has in part been based.

Fractures of the skull and spine have purposely been omitted, as these lesions are of importance, not so much from the question of the fracture, but rather from associated injury of the underlying tissues, a consideration of which would be far beyond the purpose of this small treatise.

My thanks are due to the members of the Staff of the London Hospital for their kind permission to use radiographs of their cases.

A. J. W.

13, WELBECK STREET, W.

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FRACTURES AND SEPARATED EPIPHYSES

CHAPTER I

ÆTIOLOGY, VARIETIES, SYMPTOMS, AND PATHOLOGY, OF FRACTURES

FRACTURES and separated epiphyses are perhaps the most common of all injuries, and although in many cases the results may be but slight and easily remedied, in others the immediate effects may be much more serious, the treatment necessary much more prolonged, and the after-results so severe as to prevent the patient from ever returning to his work. To these after-results so much attention has of late been drawn owing to the claims made under the Workmen's Compensation Acts and the Employers' Liability Acts, that it is important that more attention should be given to this type of accident. The value of different modes of treatment usually carried out should be more fully appreciated, and the fact realized that anatomical and functional restoration do not necessarily go together. Fractures may occur at all ages, whilst separation of the epiphyses is of necessity limited to the age before which junction of the individual epiphyses with the shaft takes place. They may be due to many causes, which are best divided into predisposing and exciting.

Predisposing Causes—*Age.*—Although fractures may take place at practically any age, they are more prone to occur at those ages during which the patient is most exposed to external violence; but apart from external violence other predisposing causes, which will be considered more fully presently, are more likely to occur at different ages—for instance, the lack of ossification in childhood allows the shaft of the bone either to readily bend or break, whilst the absorption and rarefaction of the bone in old age, again, makes certain classes of fracture extremely common. The relative frequency of fractures at different ages is well shown by the following table taken from the London Hospital statistics of the in-patients for the ten years 1900-1909 inclusive.

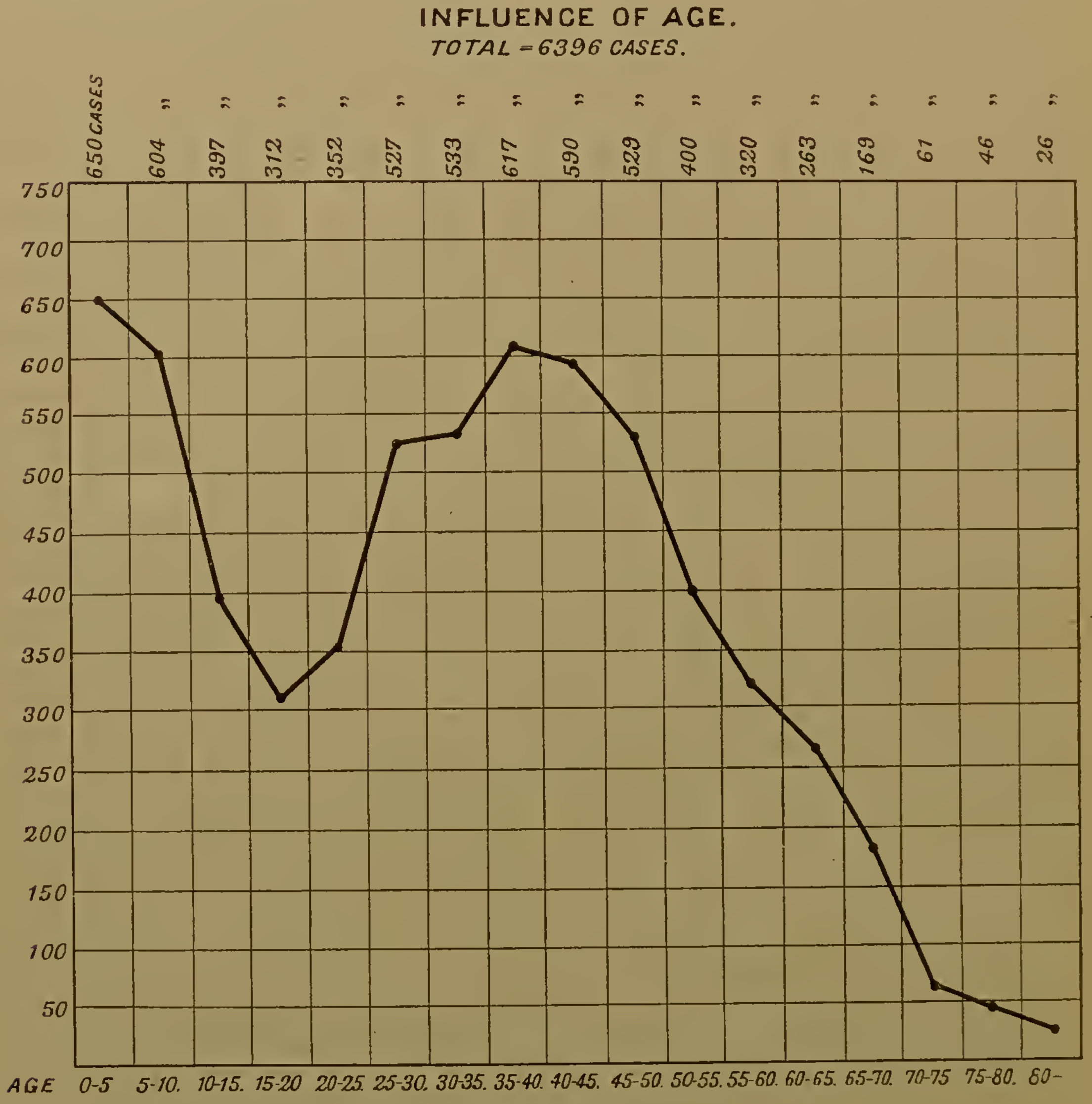

TABLE I.

Sex.—As a general rule men are much more prone to suffer from fractures than women. From the nature of their work they are more exposed to direct trauma, and during youth and adult age fractures greatly predominate in the male sex. In early infancy, however, there is, as regards their environment at least, no difference between the two sexes, and thus fractures are equally common among them. In old age, as already mentioned, rarefaction is very likely to occur, especially in the long bones; but such rarefaction is much more marked in women than in men, probably owing to the fact that their lives have been less devoted to exercise, and thus the bones are thinner, whilst in later years their weight increases more rapidly than a man's—thus, fractures of a certain type, especially those of the lower end of the radius and of the neck of the femur, are very common in old age in

INFLUENCE OF SEX AT DIFFERENT AGES.
TOTAL MALES = 4909.
TOTAL FEMALES = 1487.

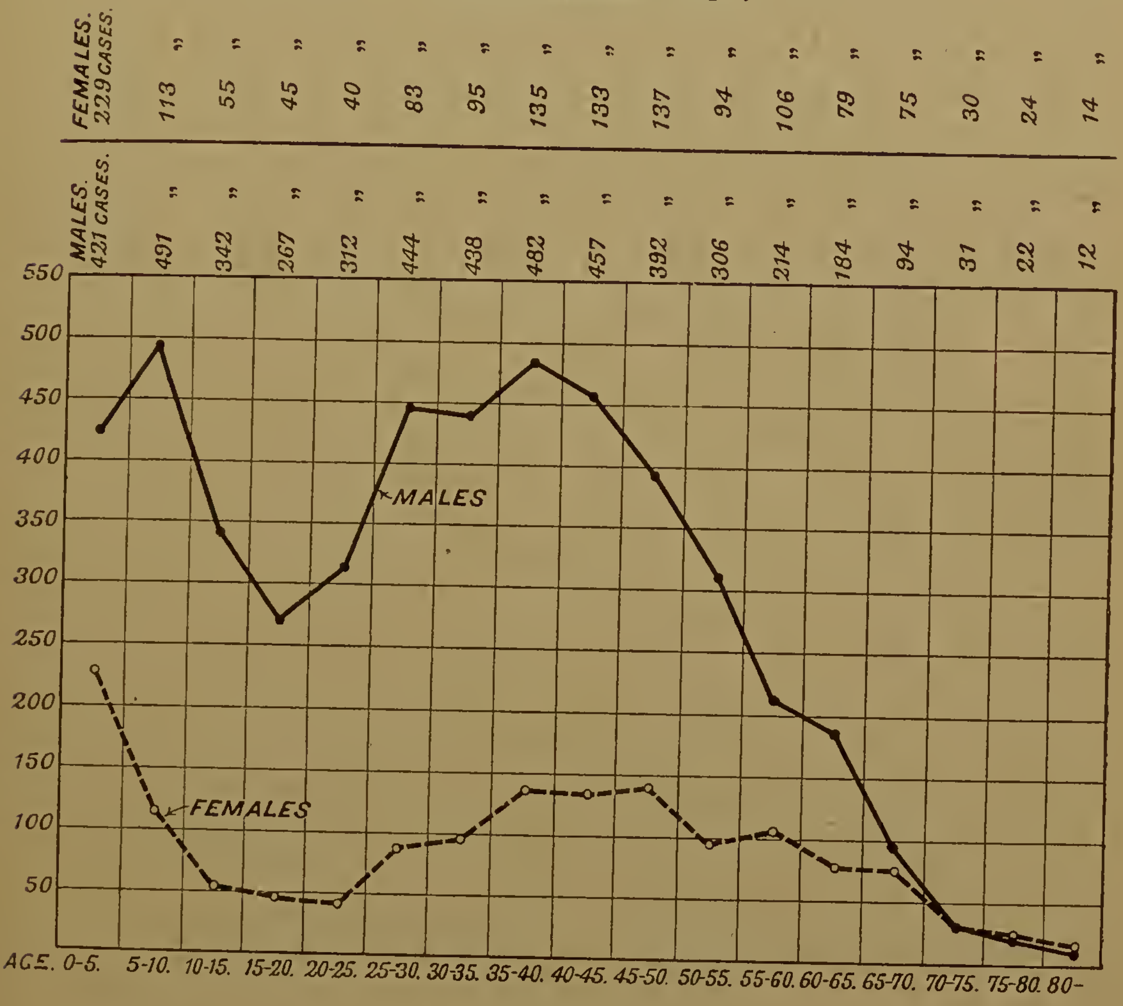

TABLE II.

the female sex, so much so that, taking all cases at these ages together, fractures are as common in the female as in the male.

This relationship, both for the total number and for fractures taken at different ages, is well shown in Table II., compiled from the same cases as in Table I.

Atrophy of the Bone.—Atrophy of the bones may occur under many conditions, thereby strongly predisposing to a fracture. The general atrophy occurring in old age has already been sufficiently dwelt upon. A somewhat similar condition of atrophy of all the long bones may occur in certain nervous diseases. In general paralysis such a condition has long been recognized. Bianté[1] in 1877 described a condition in the long bones of increase in the fatty tissue and thinning of the bony trabeculæ, whilst Rogers and Brown[2] showed that in the ribs of such patients there was a marked decrease in the lime salts. These observations have been many times confirmed, and are of importance in that such patients may suffer fractures from very slight violence, and actions in the criminal courts may be unjustly brought against their attendants and warders. Charcot[3] has described thinning and softening of the bones in tabes dorsalis of such an extent that not only are the bones more readily broken, but spontaneous fracture may even take place. In a single limb atrophy of the bone is well seen in cases of anterior poliomyelitis, which occurring at an early age is usually associated with lack of growth of the bone. Such bones may be very brittle, and break with very slight violence, and may then show but little tendency to unite. Another nervous disease showing a similar condition is syringomyelia, especially if associated with trophic changes, such as Charcot's joints or Morvan's disease. In all cases of disuse a certain amount of atrophy and rarefaction is common. If this disuse be dependent upon disease and ankylosis of a joint, the rarefaction is likely to be more marked; thus, cases of ankylosis of the knee-joint due to old tuberculosis often show marked osteoporosis of the neighbouring portion of the tibia and femur, which increases the tendency of these bones to fracture.

Disease of the Bone.—Both local and general forms of disease occur in the bones, and render them more prone to fracture. An uncommon form of general bone disease is osteogenesis imperfecta, where from birth the bones are, as regards their lime salts, poorly formed, so that many fractures may take place, especially in the long bones, and ultimately lead to very marked deformity (Fig. 1). Osteomalacia and fragilitas ossium are conditions associated with marked softening of the bone. In the former condition, which usually occurs in pregnant women, the bones generally show marked bending, and the diagnosis is not difficult. Fractures in such cases are often greenstick in nature. In the case of fragilitas ossium, if such a disease exist as a separate condition, the bones are more likely to be brittle than soft, so that there is less general deformity.

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[1] *Lond. Med. Rec.*, 1877, p. 60.

[2] "Fractured Ribs in Insane Persons," *Liv. Med. and Surg. Rep.*, vol. iv., p. 85.

[3] *Syd. Soc. Trans.*, ser. ii., p. 305.

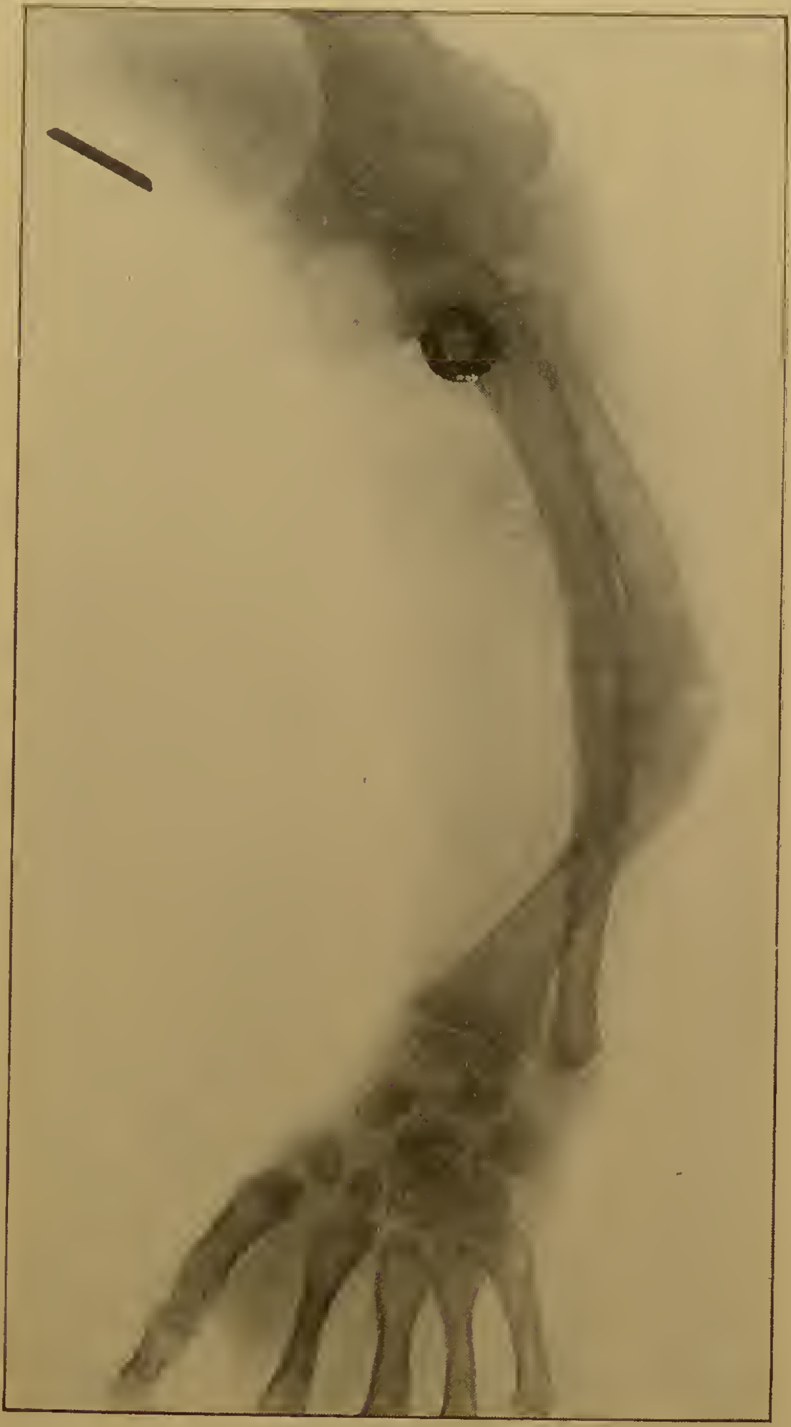

FIG. 1.—SPONTANEOUS FRACTURE OF THE RADIUS IN A CASE OF OSTEOGENESIS IMPERFECTA. (Mr. Openshaw's Case.)

In severe cases of rickets, again, the bones may be so softened that fractures readily occur. This is not common in the slighter forms of the disease, but in some advanced cases the tendency may be so marked that the condition of the child closely resembles that of an osteogenesis imperfecta. In this disease also the fractures will tend to be of the greenstick variety, owing to the softening. Although they occur so readily, there is as a rule no failure of union. In the present day such extreme cases of rickets are unusual; the slighter and more common types, although leading to considerable softening and deformity, are not commonly associated with fracture, owing to the large amount of new bone formed.

Syphilis may cause spontaneous fracture of a bone. This may be due to a localized gummatous change leading to local absorption and atrophy, or from diffuse syphilitic osteitis, as in a case of fractured patella recorded by Johnson.[1] Locally, any form of new growth of the bone, whether primary or secondary in nature, may lead to so much erosion that a fracture results—either spontaneously or from a force less than sufficient to break a normal bone. In many cases of primary growth the local symptoms are enough to call attention to the disease before fracture takes place, but in those of secondary deposits the yielding of the bone is often the first thing which calls attention to the secondary growth.

Some cases of extensive necrosis may be sufficient to lead to a complete separation of the two ends of the bone. This is perhaps more common in the smaller bones. It may sometimes be seen in cases of very severe alveolar abscess associated with much destruction of the bone. In the case of the long bones the width of the bony tissue is so great that infection sufficient to destroy its whole thickness will not be localized to small areas, and this spontaneous fracture does not usually occur.

Hydatids and other cysts of bone may act in the same way as localized growths, as may also some cases of localized tuberculosis.

Long-continued pressure upon a limited area of bone may lead to marked atrophy, and ultimately cause fracture. Such a condition may be seen in some cases of advanced aneurysm, and of pressure from innocent or malignant tumours which have not yet invaded the bone.

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[1] *Trans. Roy. Med. Soc.* January, 1909.

Exciting Causes.—The exciting causes of fracture are three in number: Indirect violence, direct violence, and muscular action.

Indirect Violence.—In indirect violence the fracture takes place at some point other than that to which the violence is applied. It is best shown in the case of falls. Thus, an elderly woman slipping off a chair or step may fracture the neck of her femur, or a patient strongly everting his foot may fracture his fibula about 1 inch above the inferior tibio-fibular articulation. Again, the more common varieties of fracture of the clavicle are due to falls upon the outstretched hand. Such fractures are rarely comminuted, but are very prone to be spiral or oblique in form, and may be associated with a dislocation.

Direct Violence.—In these cases the bone breaks at the site of the violence. If occurring where there are two parallel bones, both of these are fractured at the same level; thus, if the leg of a patient be run over by a heavy vehicle, both tibia and fibula may be broken across. A kick from a horse in the chest may lead to a fracture of a rib or ribs at the site of violence. These fractures tend to be comminuted, and if the violence be sufficient the soft tissues over them are often lacerated, and a compound fracture results.

Muscular Violence.—If all varieties of fracture be considered, muscular violence is a rare cause, but in certain types it is the most common factor. Nearly all cases of fracture of the patella are due to a sudden and forcible contraction of the quadriceps muscle; fractures of the olecranon may be due to a similar action of the triceps; whilst more rarely fracture of the os calcis, fracture of the anterior superior spine of the ilium, or separation in part of the upper epiphysis of the tibia, may be dependent upon like causes.

Simple fractures—that is, fractures unassociated with open wounds or any other complications—are the most common. They may be considered under the following headings:

Single Fractures.—The shape and appearance of these is very variable. It is dependent partly upon the nature of the violence, and partly upon the structure of the bone at the site of the injury. Fractures due to muscular violence, and many forms of fracture due to direct violence, are transverse. Closely allied to these are separations of the epiphyses.

Fractures of the middle of the shaft of the femur, of the junction of the lower and middle thirds of the tibia, and of the clavicle, are often oblique. The obliquity is rarely constant in its direction, and is probably largely due to the direction of the violence, as well as to the structure of the bone. In other cases, again, the line of fracture is spiral. Such a condition is sometimes seen in fractures of the shaft of the humerus, and less commonly in the tibia. Rarely the bone may be split in its long axis, or this condition may be combined with a transverse lesion to form a **T**- or **Y**-shaped fracture. Such a fracture is not uncommonly seen in the lower end of the femur or humerus, and in the upper end of the tibia.

Greenstick Fractures.—In this variety the bone is partly bent and partly fractured. It gives, in fact, as a fresh or green stick would. It is most common in young children, for in them the bones are softer, less brittle, and more cancellous. The bones of the forearm and the clavicle are most commonly affected. In the case of the latter bone the concave side remains intact, whilst an irregular fracture is present on the convex side. Such fractures may give at the time but few symptoms. If the line of the bone be but slightly altered, there will be no crepitus and no increased mobility; the local pain is, however, generally severe. Later on a large mass of callus may appear, and make the condition obvious. In other cases the bone may be markedly bent, but there is no apparent separation of the two ends.

Greenstick fractures are much more rare, but may undoubtedly occur in adults. The rib in cases of fracture from indirect violence may be split at the angle, but the two portions incompletely separated. Elsewhere it is more likely to occur if there be some abnormal softening of the bones. Apart from greenstick fractures, there are other incomplete forms. Thus, a splinter or small portion of the bone may be separated without loss of continuity of the whole shaft. Such lesions will give only local pain, with perhaps the sensation of a small freely movable portion if sufficiently near the surface. They are found not to be uncommon since radiography has come into more general use.

Comminuted Fractures.—In these cases the ends of the bone are severely broken in more than one place, so that several loose fragments may be present. They are most common in cases of fracture from direct violence, and are thus often associated with severe injury to the soft tissues. They will vary on the one hand from cases where, in addition to the fracture of the shaft, there are one or two loose fragments, to those where a portion of the bone is completely pulped, as in cases where a limb is run over by the wheel of a heavy vehicle. The symptoms are generally well marked.

Impacted Fractures.—By an impacted fracture is meant one in which the ends of the bone after separation are forcibly driven together in such a way that they become joined, so that no crepitus or abnormal movement can be obtained. As will be readily understood, such a condition is often associated with comminution. It is more common in the parts of the bone which are largely cancellous in nature, such as the lower end of the radius and the upper ends of the tibia and femur, and is often dependent upon direct and considerable violence. If the position of the distal end of the bone be nearly in its normal relationship to the proximal at the line of impaction, but little deformity will result, and nothing beyond slight shortening may be appreciable. In such cases it is often preferable to leave the impaction unreduced. If, however, the relationship of the two ends of the bone to one another has altered at the line of impaction, much deformity may result, associated with considerable loss of function. In such cases, if there be no counter-indication, every effort must be made to reduce the impaction before further treatment is considered.

Other varieties of fracture are often described, but these will best be considered under Complications.

SYMPTOMS

The objective and subjective symptoms of a fracture may be so marked that no difficulty will be experienced in arriving at a diagnosis. On the other hand, they may be so slight that it is only by the use of radiography that their presence can be determined, and since this aid to diagnosis has come into more general use many new forms of fracture have been described.

The presence of symptoms will depend largely upon the bone affected. In the case of the more important bones—*e.g.*, femur — the function of the limb will be seriously impaired; while in the case of fracture of the smaller bones —*e.g.*, those of the hands—the effects will be much less obvious, and the condition readily overlooked.

At the time of the injury the patient may suffer much pain, and may distinctly hear and feel the bone crack. Such a history is of great importance, being simulated only by the rupture of a ligament or tendon. Some or all of the following signs and symptoms will be present.

Pain.—This will depend upon the amount of injury. If it be great, as in the case of most fractures from direct violence, pain will usually be a marked symptom; while in the cases of slight injury to the soft tissues, and without any affection of the joint, the pain may be so slight as to be almost overlooked. This is more markedly so in the case of a greenstick fracture, for here not only will there be but little trauma to the soft tissues, but movement of the limb may be associated with no displacement of the fragments. This is well seen in some cases of fracture of the clavicle in young children. Medical advice may only be sought by the mothers two or three weeks after the injury, on account of the formation of a mass of callus, and nothing may have been known of the accident at the time it occurred. In the same way, the pain will be less if only one of two parallel bones is fractured from indirect violence.

In the case of severe injuries from direct violence, there will be constant pain from the bruising and laceration of the soft tissues, in addition to that characteristic of the fracture. This latter may during rest be slight, but on any attempt at movement of the affected limb it becomes more severe. There is a grinding, grating sensation, which may not only be palpable, but audible to the patients—their own appreciation of the fact that crepitus is present. They will often describe their condition as one in which the limb seems to be falling to pieces. In milder cases, where the movement between the ends is less, and where deformity is slight, they may only complain of pain on pressure. A patient with a fractured fibula may be able to walk, the movement, perhaps, only causing him slight pain, which is absent when the limb is at rest.

Signs of Local Trauma.—As a general rule this is best seen in cases due to direct violence. There the soft tissues over the bone are severely bruised and may be lacerated, vessels are more likely to be injured, and thus extravasation of blood may be very evident. If the bone be near the surface, the soft tissues will be more injured than if it be deep; thus, fractures of the tibia are often associated with severe injury of the overlying tissues, and are commonly compound in nature, while those of the shaft of the femur show as a rule much less bruising and contusion.

Indirect violence does not generally give rise to so many local signs, but if the injury be such as to implicate a joint, marked extravasation is often seen. Cases of fracture near the ankle-joint, even when due to indirect violence, are generally accompanied by excess of fluid in the joint and by surrounding œdema. Simple fractures of the shaft of a bone, if accompanied by severe deformity, may also cause much laceration of the soft tissues, with extravasation of blood.

Deformity.—This may be well defined at the site of the fracture if the bone be near the surface. In cases of fracture of the tibia and fibula, the alteration in the anterior line of the former bone is very constant and of considerable diagnostic value. The same condition is seen in the case of fracture of the ulna. In fractures of the patella, separation of the two portions is very characteristic.

If the bone be situated farther from the surface, the deformity will be most apparent in the distal part of the limb. The line of its axis will not correspond with that of the proximal portion, and rotatory changes may be apparent. Shortening in one or other direction is constant, provided that the bone is not supported by a second bone parallel to it. Thus, shortening is common with fracture of the femur, whilst it may be but slightly marked when the tibia is alone broken. Such a deformity is best shown by actual measurement compared with that of the sound side. It is rarely due to the violence, being more commonly dependent upon muscular contraction.

Each type of fracture shows a deformity which is remarkably constant, and is in the majority of cases due to this spasmodic contraction of the neighbouring muscles, a fact to which much attention has to be paid in carrying out treatment.

Abnormal Mobility.—In many cases this is the most important sign of a fracture, although the determination of its presence is not always as easy as might at first sight appear. In the case of a larger bone it will not be difficult, unless the fracture be situated near one of its extremities, when the fixation of the smaller fragment through the soft tissues may be difficult, movements at and below the joint closely simulating one another. Short bones such as the metacarpals and metatarsals will present the same difficulty. Should the bone be supported by another and uninjured bone, as in the case of the tibia, radius, or one of the ribs, abnormal mobility may be little evident, although the elasticity of the connecting ligaments may sometimes allow it to be obtained. It will be absent in impacted fractures.

Crepitus.—By this is meant the sensation of grating produced when the two rough ends of the bone are rubbed together. It is dependent upon abnormal movement, and is a sensation which can be partly felt by the two hands and partly heard. It may be as apparent to the patient as to the surgeon. If it be certain that crepitus is obtained in the length of a bone, the presence of a fracture is definite. It is, however, closely simulated by rough movements in a joint such as occur in osteo-arthritis, and if the fracture be situated near such a joint a false diagnosis is possible. Such a difficulty is prone to occur in cases of fracture of the neck of the femur in old age.

It may be somewhat closely simulated by grating within an inflamed tendon sheath. It will be absent if portions of the soft tissues, such as ligaments or muscles, are displaced between the ends of the bones, and is of course not obtainable if the fracture be impacted.

Loss of Function.—This may be complete or partial, and will depend chiefly upon the bone affected, and to a less extent upon the nature of the fracture. If a large bone, unsupported by any neighbouring bone, be completely fractured, there will be almost complete loss of use of the limb. Thus, a patient with an unimpacted fracture of the femur would be unable to walk. If the two ends be impacted there may be some function. Fractures of small and subsidiary bones may cause little or no loss of function. Thus, a patient with a fracture of a rib may complain of little else but slight pain. If a fracture of the shaft of the fibula be alone present, it may be possible for the patient to walk. Fractures of the small bones of the hand or foot may be associated with no other symptom than slight pain.

Appearance by Radiography.—Although not strictly a symptom or sign of fracture, the appearance under X rays has now become so important an adjunct in the diagnosis of this class of accident that their use must be considered. Wherever possible X rays should be employed, but at the same time it must be understood that nothing is to be more deprecated than the habit of relying wholly upon a radiograph in making a diagnosis. The limb should always be fully examined beforehand, and the radiograph regarded rather as a means of confirming the diagnosis. At the same time it is so valuable a means, not only of discovering conditions which might otherwise be overlooked, but also of estimating the amount of displacement, that it should be used wherever possible. Certain complications of fracture, such as dislocation of a neighbouring joint, may be entirely overlooked; other fractures may be so small and give rise to such slight symptoms that it may be difficult, or even impossible, to diagnose their presence without the use of X rays. Such conditions as fracture of the bases of the metacarpals, fractures of certain of the tarsal and carpal bones, and fractures of the patella, from direct violence, may pass entirely unnoticed unless a radiograph be taken on account of the pain complained of, which may be but slight. A careful radiograph taken before and after treatment will be of great value in showing how the limb is reacting to the means of treatment employed, and lack of success may thus be early recognized and rectified. It must, however, be realized that considerable experience is required to correctly interpret the condition shown on the plate; displacements may be absolutely unnoticed in a radiograph taken in one plane, whilst they may be only too apparent in one taken in another plane. At the same time, the appearance shown will largely depend upon the position of the tube and the obliquity of the rays, and considerable distortion of the true condition may thereby be produced. Lucas-Championnière[1] and Jones[2] have both laid stress upon these facts. The former has shown that a fractured bone mounted as an osteological preparation may show either no indication of fracture or marked separation of the fragments according to the position of the tube. He has also shown that an old fracture well united may show apparently complete lack of union by radiography, owing to the relative transparency of the callus. The latter has laid stress upon the fact that but seldom is perfect apposition obtained, although perfect functional results may accrue, and points out the danger of allowing patients to see their own radiographs, as great and unwarranted disappointment may thereby be caused.

For these reasons reliance must never be placed upon a single radiograph, and plates should always be taken in two planes. If there be apparently marked deformity by other means of examination, with but little in the radiograph or *vice versa*, these above facts must be borne in mind before a conclusion is arrived at.

PATHOLOGY OF REPAIR.

The pathological changes taking place at the site of a fracture are in the earlier stages identical with those occurring in any other wounded area that has not become infected. At the time of the fracture there is a certain amount of injury to the vessels, muscles, and connective tissue. From these injured tissues a varying amount of blood will escape, so that an irregular cavity is formed around the two ends of the bone. The wall of this cavity is ill-defined, and formed of lacerated soft tissues, containing portions of periosteum, and perhaps spicules of bone. The ends of the bone themselves are jagged and irregular, often being separated in part from the surrounding periosteum. If the part be kept at rest, the hæmorrhage ceases and the blood soon undergoes clotting, whilst inflammatory changes are set up in the surrounding tissues and neighbouring medulla. The vessels undergo dilatation, with an escape of serum and white corpuscles. At the same time the connective-tissue cells rapidly proliferate. At this time, then, there is a semifluid collection surrounding the ends of the bones, in which are many wandering cells. The tissues round about are œdematous and show much cellular infiltration. Within a short space of time the fluid elements are absorbed, so that blood-clot invaded with cells from the blood-stream and from the connective tissue is left. The invasion of the clot by these inflammatory cells rapidly proceeds. The red corpuscles, any dead tissue, and probably small portions of completely separated bone, are absorbed. Into the outer part of the organizing clot new loops of capillaries grow, while the proliferated connective-tissue cells gradually become more differentiated to form early fibrous tissue. At this stage the ends of the bone are connected by a mass of vascularized fibro-cellular material—in fact, granulation tissue. This mass not only surrounds the ends of the bone, but passes up the medullary canal of either end for a short distance, so that the ends of the bone, which are now smoothed down by the phagocytic action of the cells, are completely embedded in it.

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[1] *Journ. de Méd. et de Chir. Prat.*, November 10, 1907, p. 801.
[2] *Lancet*, March 21, 1908.

This fibro-cellular mass is now gradually ossified to form the provisional callus, which for descriptive purposes is usually divided into the ensheathing callus, surrounding the ends, and the medullary plug or internal callus. The ossification takes place irregularly, so that soft cancellous bone is at first formed, the amount of which is very variable, and dependent upon the apposition of the fragments. If but little distance separates the two ends, and they are in the same line, the amount of provisional callus is at a minimum. If, however, they are badly placed, and form an angle with one another, it is considerably increased.

The method of this ossification has aroused considerable discussion. Many have stated that the new bone is always preceded by cartilage formation, but it is very doubtful if this takes place in those cases where the condition pursues a normal course. It is true that in cases of non-union the ends of the bone may be capped by a layer of cartilage in the formation of a pseudarthrosis; but in this case the normal process of union has come to a stop, and other changes have been set up. The fibro-cellular material as a rule becomes gradually calcareous and ossified, it being but seldom that there is any evidence of cartilage formation in those cases where operation is undertaken to overcome deformity.

The source of origin of the bone has also led to much discussion. For many years the teaching of Ollier was fully believed—*i.e.*, that the new bone was formed directly from the periosteum, and the union of a fracture was largely brought about by ossification spreading from bridges of periosteum which still united the two ends of the bone—and in many radiographs appearances are seen which suggest very strongly the presence of such bars of bone uniting the two ends. Ossification can, however, readily take place without the presence of such periosteal bridges.

Sir William Macewen in 1881[1] first showed that formation of bone could occur from a pre-existing portion of bone without the presence of periosteum. In 1907[2] he again pointed out the importance of the bone cells in the formation of new bone. He showed that bone is developed from periosteum only when the bone cells are adherent to it, and that bone deprived of its periosteum continues to grow even if transplanted into the midst of muscles.

In the case of a fracture the vessels in the Haversian canals undergo dilatation, whilst the surrounding cells proliferate. Many of these are osteoblastic. They wander into the fibro-cellular mass, continue to proliferate, and give rise to irregular cancellous bone in the form of radiating spicules, which fuse together to form a network until the whole tissue is converted into a spongy mass of bone. In some cases they may wander into neighbouring muscles, and lead to the formation of bone there (see Complications). The importance of realizing this method of bone formation is of value in the treatment of ununited fractures.

There is considerable doubt as to whether bone is, in these cases, ever formed by metaplasia—that is, by the fibroblasts taking on osteogenetic functions.

The whole question of the metaplastic formation of bone has been admirably discussed by Turnbull,[3] and need not be entered into here.

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[1] *Proc. Roy. Soc.*, June, 1881.

[2] *Ibid.*, June, 1907; and *Brit. Med. Journ.*, June 22, 1907.

[3] *Archiv. Path. Inst. Lond. Hosp.*, vol. ii., 1908, p. 75.

This provisional callus lasts for a long time, but, provided that apposition is good, it is gradually absorbed and replaced by new bone uniting the fractured ends. This new material, known as the "permanent callus," is formed of compact bone identical with that of the original shaft, and having its trabeculæ and Haversian systems arranged in a manner similar to that of the surrounding bone, this factor being apparently dependent upon the lines of stress in the bone. This process may take many months, but in the end may lead to complete restoration, so that it would be difficult, and in some cases impossible, to tell that a fracture had taken place (Fig. 2, A). It continues to progress long after restoration of function has taken place.

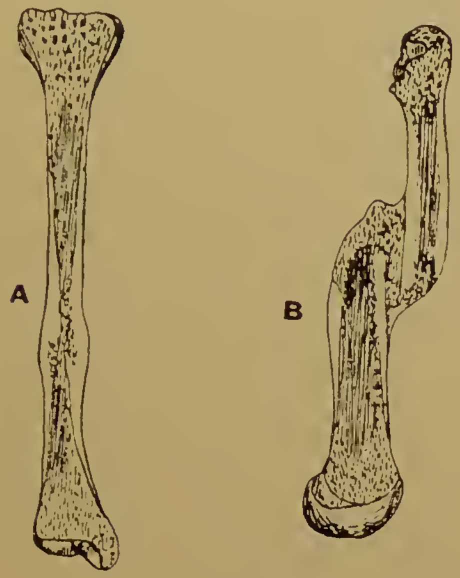

FIG. 2.

A, Union of tibia with slight displacement (London Hospital Museum, No. 492). B, Union of femur with much displacement (London Hospital Museum, No. 452).

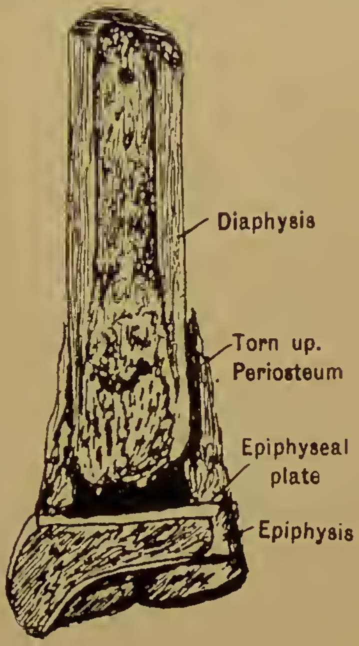

FIG. 3.—SEPARATION OF LOWER EPIPHYSIS OF RADIUS: EPIPHYSEAL PLATE DISPLACED WITH EPIPHYSIS. (London Hospital Museum, No. 405C.)

If, however, apposition is not good, a large amount of the provisional callus will persist. The cancellous bone, which in these cases is large in amount, becomes much firmer, and welds the ends of the bone together. The internal callus will also persist, so that the medullary lumen is not restored; a certain amount of compact bone directly uniting the ends will also be formed (Fig. 2, B).

The time taken over these different stages is extremely variable. It is dependent upon the age of the patient, being much more rapid in the young; on the size of the bone, proceeding more quickly in smaller bones; and upon the nature of the bone, union taking place at a much earlier date in cancellous bones, such as the ribs. It will be considered further with the special varieties of fracture.

In the case of separated epiphyses there is another factor to be considered. Not only is deformity produced at the time of accident, but a further marked shortening may develop later owing to the injury of the epiphyseal line being sufficient to prevent subsequent growth. Unfortunately, in the majority of cases the epiphyseal cartilage is carried away with the epiphysis (see Fig. 3), so that the diaphysis, in which the greater growth in length normally occurs, will be the part to show subsequent shortening, and thus marked deformity will result. In some cases this injury will only lead to retardation of growth on one side of the epiphysis, so that the bone gradually becomes curved, leading to bowing of the limb rather than shortening. If good apposition is obtained, such effects are, however, not common, and good union generally results.

CHAPTER II

GENERAL METHODS OF TREATMENT

WITHIN the last few years the treatment of fractures has undergone very considerable change. Many new methods have been brought forward which have been strenuously advocated by their introducers, often to the exclusion of all other methods, and as being applicable to all types of fracture. Owing to this many schools have arisen. On the one hand there are those who advocate complete rest until union has taken place; on the other are those who allow a certain amount of use of the affected limb—the so-called "ambulatory treatment"—maintaining that limited movement between the ends of the bones hastens union. Again, there are surgeons who strongly advocate methods of obtaining perfect or nearly perfect apposition; whilst others believe that accurate apposition is rarely obtained and is of secondary importance, and direct all their attention to increasing the nutrition of the part by massage and early passive movement. The truth probably lies in the fact that no one method is applicable to all fractures, and even when used should in the majority of cases be combined with other methods. In this chapter these different means of treatment will only be considered from a general aspect, the question as to their use being decided with the individual fractures.

Temporary Treatment.—This will include methods used to keep the limb at rest whilst the patient is conveyed from the site of the accident, and also those used to prevent movement until the permanent means of treatment can be applied. They are of importance in so far that without their use movements would be likely to take place between the two ends, sharp portions of which might further injure the soft tissues, so that the vessels and nerves would be lacerated, portions of muscle tendon or ligament interposed between the ends, or even the skin perforated, and a simple fracture thus converted into a compound. In the first case, umbrellas, walking-sticks, or other rigid bodies of a handy size, may be used as temporary splints, being bound to the limb with handkerchiefs; or if the injured limb be an arm, it may be simply bound to the side, whilst a leg may be fixed to the uninjured limb. In the second case, the patient being in bed, the affected limb is best held down with a wide strip of cloth held in position by sand-bags or other suitable weights.

To Overcome Deformity.—The deformity may be caused by the primary violence directly displacing the ends of the bone, in which case they often overlap and may be automatically locked, or it may be produced by spasm of the muscles pulling either one or both portions out of their normal position. Although these two factors are quite distinct, they often act together. If the first factor be the most marked, reduction will have to be brought about by manipulation, usually with the patient under a general anæsthetic. If the deformity be slight, attempts may be made without an anæsthetic, care being taken that all the muscles which are maintaining the deformity are relaxed by the position of the limb. This will, however, often fail, whilst reduction will be easy when the patient is anæsthetized, as here all the muscles are flaccid. This relaxation must in this case also be aided by so placing the limb that the contracted muscle is loosened. Where deformity is due to muscular contraction, reduction under an anæsthetic is also easy, but the deformity tends to recur as soon as the patient comes round. In some cases this may be prevented by the application of splints or by the use of massage; in the majority, however, this deformity, being produced by contraction of muscles, takes the form of shortening of the limb from overlapping of the ends: extension will then have to be applied. It is often possible, however, by judiciously placing the limb so that contracted muscles are relaxed, and by the early use of massage, to save the patient from this troublesome and somewhat unpleasant form of treatment; but there are cases, notably those of fracture of the shaft of the femur, where this method of treatment excels all others.

As a type of the method of applying extension, a case of fracture of the middle of the shaft of the femur may be considered. The surgeon must be supplied with the following materials:

1. A stirrup. This is made as follows: A piece of wood shaped as in Fig. 4, *a* is taken. To one surface is applied a band of adhesive plaster about 2½ to 3 feet long, the piece of wood lying in the centre of this. To the other side of the wood is applied a second portion of strapping of such a length that when the wood is 2 to 3 inches below the foot the inner side reaches to the groin, the outer to the great trochanter. This piece being longer than the first, two adhesive surfaces are left, as in Fig. 4, *b*. A small strip of adhesive plaster may now be wound round the wood and the long strips so as to bind them all firmly together.

2. Strips of adhesive plaster about 2 inches wide, and varying in length from 8 to 24 inches. Both the width and the length should vary with the size of the limb.

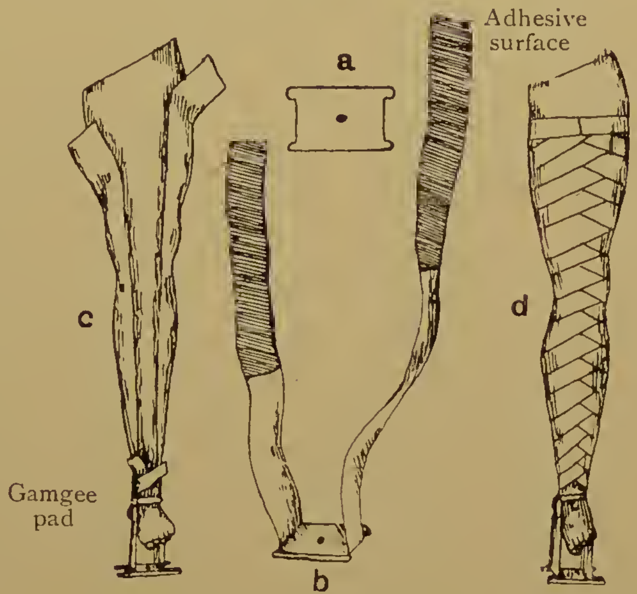

FIG. 4.—APPLICATION OF EXTENSION APPARATUS.

3. A strip of Gamgee tissue or cotton-wool 3 inches by 12 inches. The patient is anæsthetized if necessary, and the leg cleaned and shaved. The strip of Gamgee tissue is now wound round the ankle, and the stirrup applied as in Fig. 4, *c*, with the adhesive surfaces of the plaster in contact with the inner and outer sides of the leg respectively. The short strips of plaster, having been heated or moistened with ether, are now wound round the leg from the ankle upwards. The two ends are made to overlap obliquely, and each strip overlaps that below for one-third of its width, strips of increasing length being required as the wider parts of the leg are reached. They must be carried up well above the knee, so that extension is not made on the ligaments of this joint.

It will generally be sufficient to carry it two-thirds of the way up the thigh. The ends of the last band are made to cross directly instead of obliquely, and the ends of the wings of the stirrup are turned down, and a second band applied round these to finish off the upper limit neatly (see Fig. 4, *d*). The limb should be left in this condition for twelve hours, so as to allow the plaster to become firmly adherent; after this the extending weight may be applied. A chain is passed through the hole in the stirrup and knotted on the foot side; the other end is carried over a pulley fixed to the end of the bed and the weight attached. This consists usually of a tin can containing shot, the can being so graduated that each division corresponds to 1 pound weight of shot. For adults a weight of 5 pounds should be first applied, and gradually increased by 1 pound to about 10 or 12 pounds. If more than this is applied, the plaster will probably slip off the leg and be useless. In some cases it is necessary to apply a heavier weight, when a special apparatus will have to be used (see Fractures of Femur). In younger children the weight applied should be much smaller, and in those under five should not commence with more than 2 pounds, being gradually increased. In all cases the weight may be increased until the patient can take no more—*i.e.*, until it causes pain. It should never be increased above this. Any other rule giving the amount of weight to be used for different ages is valueless, as the muscular condition of patients is extremely variable. This extension apparatus can be applied equally well to the arm.

As a general rule extension is applied in combination with some form of splint which is used to overcome any lateral movement and to keep the part fixed. Some surgeons make use of it without any form of splintage. The method of Bardenheuer is best suited for this purpose. The steps of this method, as described by Pringle,[1] are as follows:

Extension apparatus is applied as described above, but in all cases extends up to the level of the perineal groove. The knee-joint is, however, left uncovered by the circular strips, so that movements at this joint may be carried out. A pad is placed beneath the knee to maintain a slight degree of flexion, and a weight that may be anything up to 35 pounds is attached. By this means shortening is overcome. Lateral displacement may be got rid of by applying loops of adhesive plaster around the limb above and below the fracture, weights being applied in such a way that they pull in a direction opposite to that of the displacement. If there be any rotatory movement, strapping may be wound in a spiral way round the limb, and a weight attached to its extremity. The spiral is wound in such a way that when it becomes unwound, as by the action of the weight, the limb is rotated in a direction opposite to that of the deformity. This method has the benefit that stiffness of the joints, so common after prolonged splintage, is largely reduced, but it suffers from the same drawback that massage cannot be applied in the early stages owing to the presence of the adhesive plaster.

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[1] *Practitioner*, August, 1909, p. 195.

Fixation Apparatus.—When deformity has been overcome by manipulation, some form of retentive apparatus is usually applied to maintain the limb in its correct position until union has occurred. If extension is being applied, the retentive apparatus is used whilst the deformity is being overcome. Formerly attempts were made to fix the fragments absolutely when once the deformity had been reduced, and to maintain this fixation until union had occurred. Many surgeons now, however, are accepting in part at least the views of Lucas Championnière put before the Société de Chirurgie in 1886. In more recent articles[1] he states that absolute fixation of the fragments is not the most favourable condition for repair, and that slight movement combined with massage favours the vitality of the bone and of the surrounding structures, whilst partial ankylosis of joints, which is so common after prolonged and absolute fixation, is entirely prevented by this method.

Most English surgeons are, however, agreed that some form of fixation apparatus is in the majority of cases necessary, but wherever possible massage and passive movements should also be used. The method of fixing an injured limb, such as a leg, firmly in splints for three to four weeks is to be strongly condemned. At the end of that time the vitality of the soft parts is very poor, the movements of the muscles are impaired, and contractions may have taken place. The limb is wasted, the subcutaneous tissues are often hard, and the contour of the limb is angular rather than rounded, whilst movements at the joints are much limited. So poor is the general condition of the limb, that a prolonged period may elapse before use is regained. This question will be discussed further when the treatment by massage and passive movement is considered. It will be sufficient here to state definitely that wherever possible a retentive apparatus should be such that it supports the limb, but can be readily removed for a period each day, during which massage, and perhaps passive movement, can be performed.

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[1] *Brit. Med. Journ.*, October 3, 1908, p. 981; and *Medical Annual*, 1909, p. 292.

The forms of retentive apparatus are as follows:

1. *Splints.*—These may be made of various substances, such as wood, metal (either as plates or bars), leather, or poroplastic felt. If of wood, the surfaces should be flat, the irregularities of the limb being filled up by careful padding. This is much more satisfactory than having wooden splints moulded, as these are of fixed size and shape, and cannot be made to fit all limbs. They may be slightly hollowed on the inner side, so as to maintain the padding in position. The other varieties are so moulded as to partially envelop the limb; those with metal plates can be adjusted by sliding movements of the plates, whilst the leather and poroplastic splints are moulded to accurately fit the injured limb itself. These varieties will be considered more fully with the individual types of fracture.

Splints, although of multitudinous forms, may be considered to fall into one of the three following categories:

(*a*) Simple fixation splints. These are used simply for the purpose of keeping the fragments in their normal position after the deformity has been corrected. They should either accurately fit the part, or, in the case of the limbs, should be carefully padded. The padding is applied as a layer of tow and wool of uniform thickness over the splint, being maintained in position by a covering of calico or flannel stitched round the back of the splint, and thus readily removable. The limb being applied to this, all hollows are filled up with pads of cotton-wool, similar pads being also applied to any points at which it is desired to exert pressure.

These pads before being applied are freely dusted with powdered boric acid, which is also sprinkled wherever the part is likely to sweat or shows any bruising.

In some positions, such as at the sole of the foot, a layer of boracic lint may be placed. The splints must be of such a length that, wherever possible, they project beyond the joints above and below the fracture, so that the limb may be fixed by the splint. They should be secured by straps and buckles passing over pads of cotton-wool rather than by strips of adhesive plaster. By this means the amount constriction can be readily adjusted as the swelling of the limb decreases, and the splints may be easily removed, either to apply daily massage or to readjust them if the deformity, as shown by radiography, has not been well overcome.

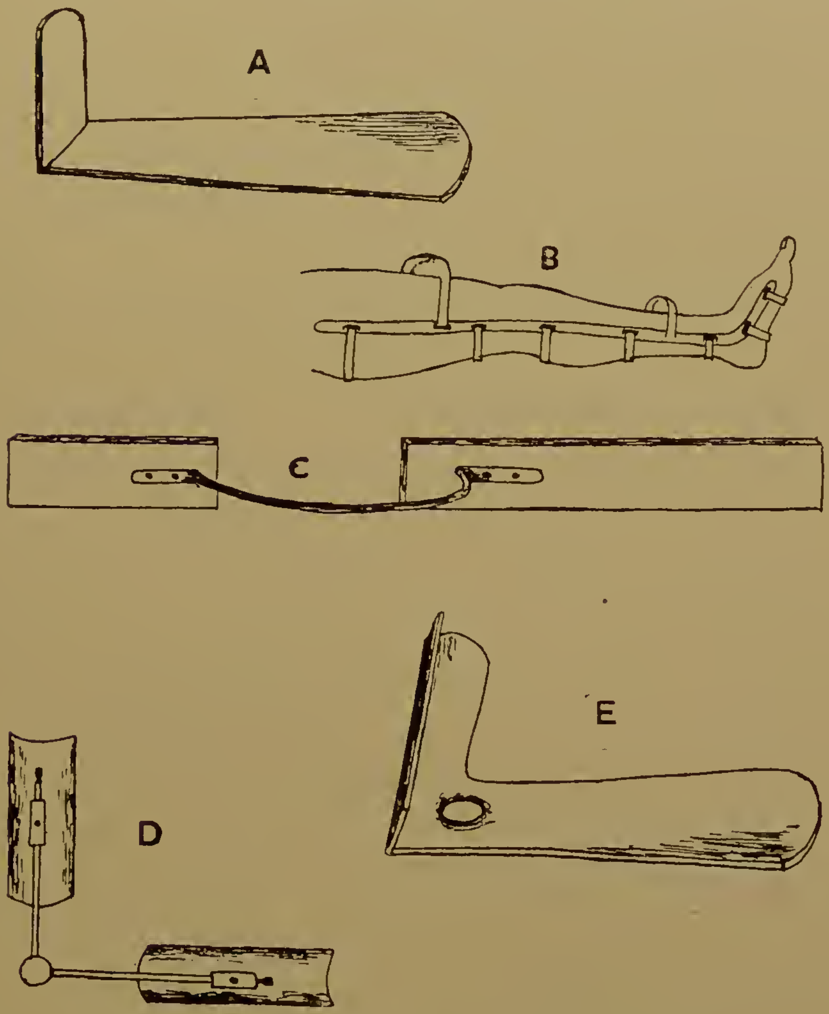

FIG. 5.—DIFFERENT TYPES OF SPLINT.

A, Back splint for leg; B, aluminium bar splints; C, interrupted wooden splint; D, metal angular splint; E, Sharpe's splint for leg.

Above the straps a bandage may be applied if desired, but it is usually unnecessary. The limb should always be examined the day after the application of the splints, for evidence of local pressure or too tight a constriction, the latter very readily occurring, however carefully they are applied, owing to the subsequent swelling of the limb. Examples of these splints are seen in Fig. 5.

(*b*) Splints which aim at overcoming deformity. A splint of this type is such that, in addition to simple fixation, the shape of the splint largely determines the position of the limb. It is so made that a constant deformity of a given type of fracture is overcome. An example of such is seen in the case of Carr's splint, used to overcome one of the deformities of a Colles's fracture.

(*c*) Splints which aid in causing direct extension. The best example of these is a Hodgen's splint. It will be fully described with fractures of the femur.

2. *Plaster Bandages.*—These are made of a coarsely-meshed muslin or a stout butter-cloth impregnated with plaster of Paris, which, after being soaked in water, are applied to the limb—as a rule after union has taken place, and then as a support to prevent refracture of the newly-formed callus. As usually applied they are bound round the limb, allowed to set hard, and removed after a period of two to four weeks has elapsed. Although this method is extremely good for some cases of disease of joints and for some deformities, for simple fractures the results are bad. The joints become fixed, the limb atrophied, and adhesions of tendons are very likely to form, a long time elapsing before the limb becomes functional, so that it is doubtful if this method should ever be used. These drawbacks may be overcome by the method regularly adopted at the London Hospital, of splitting down the plaster immediately after application, so that it can be removed for daily massage and passive movements. By this means it becomes a most useful adjunct to treatment.

V. Brun[1] advocates the immediate application of plaster, the patient in the case of fractures of the lower limb being allowed to walk as soon as the plaster is set. Buchanan[2] advocates a similar line of treatment in the case of osteotomy of the femur—the so-called "ambulatory treatment." In such cases, however, the plaster must be close-fitting, which, for the reasons given above, is objectionable; and in any case it is much preferable in the early stages to keep the patient in bed, allowing massage and passive movements, which are readily controlled, rather than the irregular movements and jarring of walking. These, it is true, may to a certain extent aid union, but may be readily overdone, and then prove a danger ; moreover, to obtain a well-fitting plaster, it is essential that sufficient time should have elapsed to allow all swelling to subside. To aid the immediate application of plaster in the case of fractures of the femur or other bones of the leg, many instruments have been invented to give powerful extension, which is kept up while the plaster is applied, and thus shortening is prevented. The simplest of these is that of Echols,[1] which is portable, but, as pointed out, this method is not to be encouraged.

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[1] *Beit. z. Klin. Chir.*, 1903.

[2] *Practitioner*, April, 1908.

The plaster may be applied as follows :

The surgeon, wearing rubber gloves, applies a layer of cotton-wool of medium thickness around the limb. This should extend to one inch beyond the intended limits of the plaster. Over it is wound a single layer of a domette bandage of the same extent as the plaster. In the line of the subsequent divisions are now placed two thin strips of tin, their ends being fixed by a single turn of the domette bandage. The plaster bandages, having been thoroughly soaked in a basin of warm water to which a pinch of salt is added, are now squeezed fairly dry and wound round the limb. The first layer should be lightly applied, the succeeding ones embracing the limb firmly ; by this means, and owing to the presence of the cotton-wool, undue constriction is prevented. After each bandage is applied, the surface is smoothed down, and a certain amount of plaster paste added and rubbed in, so that a smooth surface is gained. In the case of a fracture of the lower end of the tibia or fibula, about five or six bandages will be required. The condition is now as shown in Fig. 6. The projecting portions of cotton-wool are turned back, and welded with more plaster paste into the surface of the casing. By this means the ends are neatly finished off A sharp scalpel is now taken, and the plaster divided in its whole length, the two metal strips being cut down upon so as not to injure the leg. The strips are removed by gently pulling one end, and the plaster lightly bandaged to the leg until it is firmly set. By this means two accurately fitting halves of a plaster case are formed, which may be readily removed for massage and passive movements.

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[1] *Annals of Surgery*, January, 1909, p. 107.

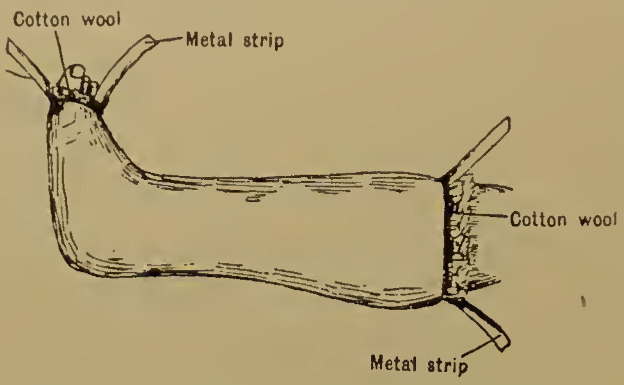

Fig. 6.—Plaster of Paris Bandage applied.

3. *Croft's Plaster.*—This is another method by which a plaster casing is applied in two separate halves so as to be readily removable. A piece of thick flannel and two pieces of lint are cut out, as in Fig. 7, the sizes of these being determined from a paper pattern cut to the shape of the leg. These three pieces make only one half of the plaster, so that in all there will be two pieces of thick flannel and four of lint. For heavy patients a double thickness of flannel should be used. As seen in the figure, the flannel is somewhat smaller than the lint. A paste of plaster of Paris and water is made, and one portion of the flannel, which has been previously soaked in hot water, is wrung out and thoroughly soaked in this paste. All excess of plaster is removed by running the flannel between the approximated hands of an assistant. It is now laid on the rough side of one of the pieces of lint, and the other piece of lint applied to its surface, so that the flannel impregnated with plaster is sandwiched between the two layers of lint. This half of the plaster is now applied to the inner or outer side of the leg, and firmly bandaged on so that it accurately fits. The other half is prepared in a precisely similar manner, and

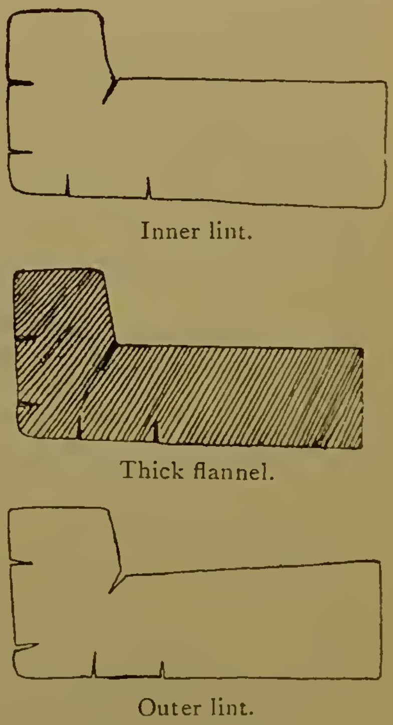

Fig. 7.—Croft's Splint.

bandaged to the other side. If properly made, the two halves should overlap by about ½ inch down the front and back of the leg. When firmly set, which will be in about twelve hours, the bandage is undone and the two halves separated. The edges are trimmed, and may be bound with adhesive strapping. When the patient is walking about, they are bandaged in position, and form an efficient support, which may be readily removed for massage and movements.

Many surgeons have a great belief in this variety of plaster, and Sir Watson Cheyne[1] advocates its use for fractures of the leg three or four days after the accident, the patient, however, keeping to his bed until union is fairly advanced—*i.e.*, three to four weeks. Most surgeons prefer to use splints during this period, as inflammatory œdema may still persist, and their use more readily allows the surgeon to alter the sites of pressure if there be any deformity. The Croft's plasters do not fit so absolutely as the divided bandages above mentioned, and are more difficult to apply. For these two reasons precedence has been given to the former method.

4. *Gum and Chalk Stocking.*—This is a method which has largely fallen into disuse of late years, but is still strongly advocated by some surgeons. Its use, however, is limited almost wholly to cases of fracture of the leg. It is prepared as follows: Ten ounces of a saturated solution of gum arabic are mixed with ½ pound of powdered chalk to form a firm paste. This is prepared twenty-four hours before use. Three stockings are now taken of different sizes—the first to fit the patient's leg, the second a size larger, and the third still another size larger. These stockings are made of thick woven cotton. The leg having been shaved and well oiled, especially between the toes and over the heel, the smallest stocking is applied inside out, so as to have the smooth side against the skin. The gum and chalk mixture having been rubbed thoroughly well into this, the second stocking is

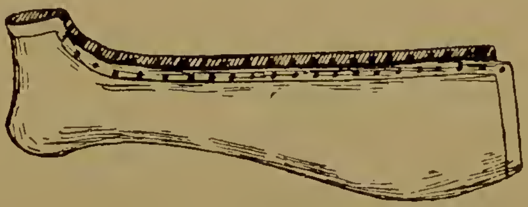

FIG. 8.—GUM AND CHALK SPLINT COMPLETED.

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[1] *Manual of Surgical Treatment*, London, part iii., p. 154.

taken, the toe extremity is cut off, and it is put on over the first one. This is easily accomplished if it be turned inside out and rolled up the foot and leg by a process of invagination. During this time the first stocking is held tight at the knee by the patient, and the second one is also stretched tightly up the leg by him while more gum and chalk is rubbed in. The third stocking is applied in a similar manner, the toe portion also having been cut off. More gum and chalk is now rubbed in, and the whole, being hung up by the projecting stocking toe and a bandage round the knee, is left to dry. This will take from twelve to eighteen hours. It is then cut down the anterior line with plaster cutters and removed. The upper portion is cut off either above or below the knee, according to the nature of the fracture. The toe extremity is also cut off at about the level of the base of the toes. The borders are bound with adhesive plaster, and holes punched at regular intervals down the anterior margins, so that it may be laced up the length of the leg (Fig. 8).

The objection to this form of retentive apparatus is that it is very troublesome to prepare, and is not so strong as the plaster of Paris.

5. *Silicate Plasters.*—These plasters are made as follows: A mixture of potassium silicate, a fluid, is added to magnesite, a powder, to form a thick cream. Bandages of coarsely-woven butter-cloth are soaked in this, rerolled, and applied in the same manner as plaster bandages. They are then left to dry, this process taking at least twenty-four hours. The material forms a hard, firm casing, and may be put on in quite a thin layer, so that it is much lighter than plaster of Paris. It is, however, more troublesome to prepare, and is more expensive. Its great drawback is that, if divided whilst wet, it tends to fall apart, and thus does not lend itself readily to the formation of a divided plaster. For permanent encasement plasters it is very useful, but, as already pointed out, these should seldom, if ever, be used in the case of fractures.

6. *Poroplastic Casing.*—This material is extremely useful for fractures of the upper extremities, and in some of these it will often be found the most valuable splint even in the early stages. In the case of fractures of the smaller bones a

pattern of the required size and shape may be cut out of paper, and the poroplastic material fashioned from this. If it be soaked in hot water it will become quite pliable, and in this condition it is bandaged on to the part and allowed to dry, when a firm, accurately-fitting splint results. Larger splints may be made in the same way, but owing to their size they are very difficult to manipulate; therefore, wherever possible, it is preferable to have them made and fitted by an instrument-maker, who uses a steam apparatus for making the material pliable. In some cases steel bars may be fixed to the splint to strengthen it in any parts exposed to much strain. The varieties of fracture most suited to this form of splint will be pointed out in the chapters relating to special fractures.

Massage and Passive Movements.—This method, as an adjunct to the treatment of fractures, has been strongly advocated by Lucas Championnière and his followers in the French school, and there is no doubt that the results obtained by its use are extremely good. Whether, however, it should be carried to the extreme lengths which the above surgeon advocates is very doubtful. It is but right to state that his conclusions are based upon very extensive experience. His first paper in support of this method of treatment was put before the Société de Chirurgie in 1886, and was then based upon several years' trial. Since then he has strenuously continued and perfected it. His more recent conclusions[1] are as follows: "Absolute fixation of the fragments is not the most favourable condition for the phenomena necessary to repair at the site of fracture. A certain amount of movement is the necessary condition." He lays special stress upon the fact that movement not only favours the vitality of the bone, but also plays a principal part in the preservation or restoration of the muscular power, in the integrity of the circulation, and in the flexibility of the tendons, ligaments, and joints. He points out, what from the common use of radiography is now being generally recognized, that reduction of a fracture does not as a rule lead to absolute approximation of the fragments, and that such approximation is not generally necessary; that perfect function may go with imperfect anatomical restoration; and that "a certain degree of shortening is even favourable to repair and muscular power." He also shows that the use of massage and passive movements is the surest and quickest way of overcoming pain, and that muscular spasm, which is often the chief cause of the deformity, is rapidly and readily overcome by their use, so that the deformities spontaneously disappear. He even reports cases[1] of fracture of the olecranon where perfect union and restoration of function have occurred in two to three weeks after the early use of massage and passive movement alone. He points out that the two most important considerations in the use of this treatment are, first, that the massage must always be gentle, and should never cause pain; secondly, the movements must at first be absolutely passive. They should be slight, and should commence in the joints more remote from the seat of fracture. When it is possible to do so without any pain, active movements may be commenced. Massage should be repeated each day. By this means the growth of callus becomes much more rapid, so "that in a few days there is sufficient consolidation to maintain the position." In regard to the type of fractures to be treated by this method, he says: "What are the fractures in which this method of mobilization and massage may be employed? The answer is, 'All.'" In most cases of fracture of the long bones he advocates that no splint should be used at all; in others splints acting solely as supports should be employed. It is probable that there are but few surgeons in this country who will agree with all these conclusions. Of the value of massage and passive movements in the treatment of most types of fracture no one would have any doubt. To take as an example a case of fracture of the tibia and fibula involving the ankle-joint: previously these were treated by rigid fixation on splints. At the end of three to four weeks they were placed in a firm plaster for another three to four weeks, and then movements very gradually allowed. By this means a leg was produced which was much wasted and shrunken, and its vitality was greatly lowered, so that in many such cases, however great care was exercised to prevent pressure, sores, blebs, and even open ulcers, only too commonly developed. Union was delayed, so that here, as also in simple cases of fracture of the tibia and fibula, there was but little, if any, fusion at the end of three weeks. Movements at the ankle, and perhaps at the knee, were extremely limited, whilst muscular and tendon adhesions often existed. Pain was constant and prolonged, so that the unfortunate patients were kept from their work for many months, and such cases are still often seen drawing compensation under the Compensation Act for months, or even years.

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[1] *Brit. Med. Journ.*, October 3, 1908, p. 981; and *Medical Annual*, 1909, p. 292.

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[1] *Journ. de Méd. et de Chir. Prat.*, July 10, 1908, p. 481.

With the judicious use of massage and passive movements *in combination with retentive apparatus*, the course, however, is quite different. The bruising rapidly disappears, the pain becomes less, trophic or pressure sores are extremely rare, even in feeble old people, and when the splints are removed there is usually good union. The movements are perfectly free, and muscular wasting, adhesions, or contractions, practically never occur. In many such cases of fracture the patient is well able to walk at the end of three weeks.

These are, however, selected cases, and even here the massage and passive movements are used as a secondary adjunct to careful splintage.

To agree with Professor Championnière, that all fractures are amenable to such treatment, requires further consideration. Very few surgeons would agree that fractures of the patella or olecranon with much separation should be so treated. In these cases the muscular spasm is often of secondary importance; the fragments of the bone are tilted and separated by portions of turned-in aponeurosis, whilst mechanical fixation, such as by wiring, is the only form of treatment which will maintain apposition, and at the same time allow those movements which are essential to prevent adhesions in such injured joints. But few, also, would be found to agree with his statements, that a certain degree of shortening is even favourable to repair and muscular power, or that in a few days there is sufficient consolidation to maintain the position. Hence one may say that the above method, although extremely useful, and perhaps one of the most valuable, must not be looked upon as the sole means of treatment. It is not applicable to all forms of fracture, and even where used the massage and movements should be regarded as an adjunct to splintage, and not splintage as an adjunct to massage and passive movements. R. Warren[1] has collected a large number of cases showing the results of fracture under this treatment. These will be considered further with the special fractures. The main details of the treatment are as follows: The limb having been put upon a splint, with straps and buckles rather than with adhesive plaster, so that they may readily be removed, massage is started on about the third day. This should at first be performed by the surgeon himself. The accessory splints are, if necessary, removed, the limb being left in good position on the supporting splint or splints. Gentle rubbing movements are now performed, so lightly that no pain is caused, the direction of the movements being always towards the trunk, so as to aid absorption. They should be continued for ten minutes every day, and within a day or two the inflammatory exudate will be greatly decreased, pain much lessened, and the limb much more healthy in appearance. The ends of the bone being carefully supported with one hand, very gentle passive movements may be performed with the other. At the end of about ten days, according to the nature of the fracture, the massage and passive movements may be handed over to a skilled masseuse. On about the fourteenth day active movements, if they cause no pain, may be commenced. At the end of three weeks, in the case of fractures of the tibia and fibula, the patient may be allowed to walk, the bones being supported by a split plaster, which can be taken off each day for the continuance of the massage and passive movements. As soon as possible even the split plaster should be dispensed with. The precise times of application of these steps of the treatment will, of course, vary with the individual case, and will be considered further in the chapters devoted to special fractures.

Open Operation.—There are many fractures in which it is practically impossible to obtain accurate apposition of the ends by any of the previously described methods. In such cases some form of open operation will often be of great value. The selection of cases for use of this method will, however, vary greatly with different surgeons. It has already been mentioned that radiography has shown that in most cases accurate apposition is not obtained, and it has been pointed out that those surgeons who advocate massage and passive movements are of the opinion that this is of but slight importance. Other surgeons, on the contrary, are strongly in favour of restoring accurate anatomical continuity. Hence they will operate on a far greater proportion of fractures. Arbuthnot Lane,[1] who is a strong supporter of this method, states that "It was evident that the displaced fragments of a broken bone were never, or hardly ever, restored to their normal position, and that the so-called 'setting of fractures' was a myth . . . and the treatment by manipulation and splints was not based on any scientific or mechanical principles." He claims that the alteration in the axes of the two portions of the broken bone causes marked changes in the joints. "It is in consequence of these arthritic changes that the pain and disability which so often follow on fractures are due." In consequence of inquiries he made among medical men in practice, instrument-makers, large employers of labour, and labourers themselves, he states that he was satisfied that the teachings contained in textbooks as to the possibility of restoring the form of broken bones, and the satisfactory results of their treatment, were absolutely false, and that the application of the X rays verified his opinion as to the impossibility of putting displaced fragments of broken bone in accurate apposition without operative treatment. He advises operative treatment in all cases of Pott's fracture, and states that in all cases of fracture of the tibia and fibula, by direct or indirect violence, open operation is the only scientific method of treatment.

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[1] *Lancet*, July 17, 1909.

Many prints of radiographs are shown in his work and in later papers[2] which are examples of malunion in different bones, which he claims are the usual results of non-operative treatment, and show the hopelessness of any surgery other than operative as a means of treatment.

That open operation is extremely useful, and in many cases gives excellent results, is not to be denied, but, as is the case with massage and passive movements, too much is probably claimed for it, and those who advocate it regard it more as a general method of treatment than as a means to be applied only in special cases. There is no doubt that the majority of cases of simple fracture of the clavicle, humerus, forearm, femur, and leg, are followed by excellent results when treated by other means. The apposition of the fragments may be extremely good, and perfect restoration of function result. In such cases open operation is not only of no value, but additional suffering is thereby caused to the patient. There will be an increased risk, which it is true will be but slight in the hands of skilled surgeons; but such fractures may occur in parts remote from the means of obtaining perfect asepsis, and the general adoption of such a method of treatment will add greatly to the risk. The period of recovery in such cases will not be shortened by these methods, as the limb cannot be used in the majority of cases until firm bony union has occurred, and in some cases the use of wires, screws, etc., not only causes local atrophy around the material, but in many undoubtedly prolongs the time taken for firm bony union to occur.

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[1] *The Operative Treatment of Fractures*, 1905.

[2] *Brit. Med. Journ.*, May 4, 1907; March 28, 1908.

There are, however, many cases where open operation is the best, and, indeed, the only means of obtaining good results—*i.e.*, restoration of function; and the cases of malunion figured in Arbuthnot Lane's works are of such a nature. If all fractures were of this type, no doubt would arise that open operation should be used almost as a routine measure; but, fortunately, such are not the common results of fracture, and no regard has been taken of the more common conditions where far better apposition is obtained, and that, far from the setting of fractures being a myth, methods of remedying mechanical displacements by manipulation, aided by massage and passive movements to overcome muscular contraction, may be extremely satisfactory. In some cases they may fail, and then operative treatment should be undertaken; in others experience has shown that definite causes prevent reduction or firm fixation—causes which can only be dealt with by operation—and here such means would be taken early. It may be said, then, that open operation is extremely useful in some cases of fracture, but is not to be advocated as a routine measure. The conditions under which it will most commonly be used are as follows:

(*a*) *Implication of a Joint.*—Here one fragment is often small, widely separated, and cannot be controlled; accurate apposition is essential, but is often prevented by portions of the synovial membrane or capsule being interposed between the fractured surfaces; whilst extravasation of blood within the joint tends to cause ankylosis, and makes early passive movement essential—a form of treatment which can only be carried out if the fragments are firmly fixed together. A good example of such a condition is seen in that of a fractured patella.

(*b*) *Neighbouring Dislocation.*—If the dislocation cannot be reduced by manipulation, an open operation will be necessary (see Complications). An incision being thus made, the fragments may be fixed at the same time.

(*c*) *Failure to obtain Good Position.*—This may be due to the interposition of muscle, tendon, fascia, or other structures, between the two fragments—a condition which can only be overcome by open operation. If left, malunion or lack of union will occur, and the functional results will be extremely poor. Hence in most cases, if the usual means of overcoming deformity fail, an early operation should be undertaken.

(*d*) *Malunion.*—The position of the ends of the bones in which union has taken place may be so abnormal that marked loss of function results—a condition which may often, if the injury be recent, be overcome by operative treatment.

(*e*) *Involvement of Vessels and Nerves.*—The injury to one or other of these structures may be such that an open operation is requisite. In such cases it will usually be wise to fix the fragments at the same time.

(*f*) *Non-Union.*—In many such cases perfect apposition and firm fixation, such as may be obtained by operative treatment, is sufficient to allow firm bony union to take place.

(*g*) *Separation of Small Fragments.*—At times small fragments of the bone will be separated. These are often the site of attachment of some muscle, the contraction of which may have led to such wide separation that they cannot be well controlled by other means, and failure of union may result in considerable loss of power. The fragment may be cut down upon and fixed in position with a peg or screw. A good example of such a lesion is that of separation of one of the tuberosities or condyles of the humerus.

The details of the operation performed will of course vary with the type of fracture, but they will all be carried out on the following lines: With every aseptic precaution, an incision is made of such a length and in such a position that free access to the site of fracture is readily obtained. If recent, all blood-clot, and any intervening structure, such as muscle, tendon, or aponeurosis, is removed, so that the fractured surfaces are perfectly clean. In the case of older fractures it is usually necessary to remove a certain quantity of surrounding callus or fibrous tissue. Care is now taken to bring the ends into good apposition. In the case of fracture of the long bones of less recent date, this may be associated with considerable difficulty, and require firm extension by an assistant.

If the operation be undertaken to overcome long-persisting malunion, this difficulty may be largely overcome by a previous thorough course of massage and passive movements, whereby the muscles and other contracted bands are made lax and more freely movable. If such be carefully carried out, it will not often be necessary to divide any contracted tendons.

In the same way care must be taken to overcome any abnormal rotation. When it has been made clear that the ends can be brought into good apposition, steps must be taken to fix them. This may be done by the use of—

1. *Silver Wire.*—This is the method most commonly adopted, and stout silver wire is the best material. It is extremely useful in cases where the displacement is directly in the long axis of the bone, as in the cases of fracture of the olecranon or patella. Holes are drilled obliquely through the fragments, with a hand-drill (Fig. 10, B), in such a way that the joint surface is not encroached upon (Fig. 9, C), and care being taken that the apertures on the two fractured surfaces are opposite one another. It will generally be most

convenient to bore the holes from the outer towards the fractured surface in the case of the fragment lying on the surgeon's right hand, and from the fractured towards the outer surface in the case of the left-hand fragment, an assistant rotating it for this purpose. If there be much strain on the fragments or the bone be soft, it is much preferable to insert a mattress suture (Fig. 9, B), whereby the chance of the wire cutting its way out is greatly diminished. In the case of cancellous bone a cannula (see Fig. 10, A) is first passed, and the wire inserted through it, the cannula then being removed.

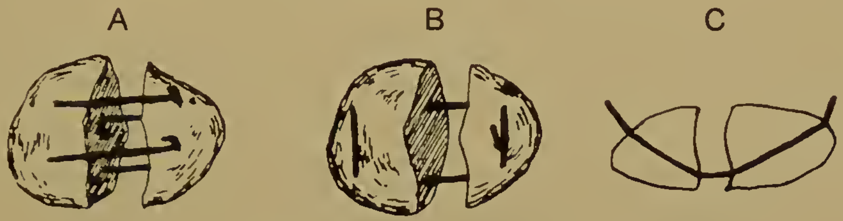

FIG. 9.—METHODS OF INSERTING WIRES.

A, Single sutures; B, Mather's suture; C, relation to articular surface.

In the case of an oblique fracture of the shaft this method is also very useful. The two ends are gripped by a wide-bladed pair of forceps, such as Peters', the blades of which are perforated to take a drill. By the use of these the ends may be held in absolute apposition until firmly wired (Fig. 11, B). The wire may here be passed as a ring round the bone.

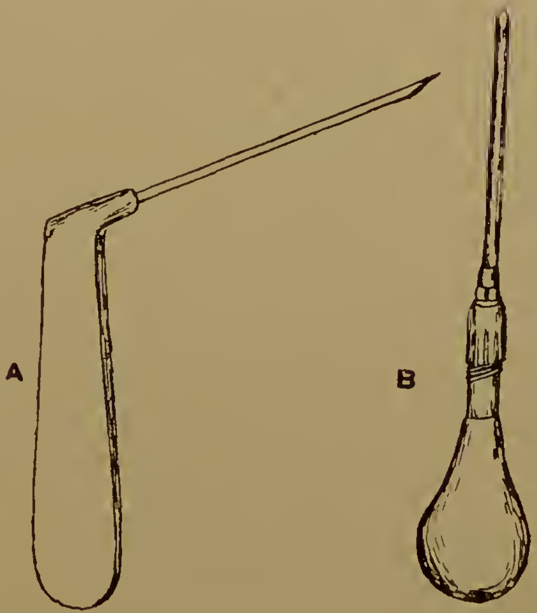

FIG. 10.

A, Cannula for inserting wire;
B, hand-drill (Lane's).

If the fracture be transverse this method is not nearly so serviceable, but if there be no lateral displacement it may be used in the manner shown in Fig. 11, A.

The ends of the wire in all cases are cut off fairly short, bent over, and hammered into the bone. A slot may be cut to receive them.

2. *Ivory Pegs, Screws, or Nails.*—These are very useful in some cases to fix small portions of bone on to the main part, especially if there be marked displacement which cannot be otherwise controlled. A good example of such a lesion is a fracture through the greater tuberosity of the humerus, which is pulled backwards by the attached muscles. Openshaw[1] records a case where an ununited head of a femur was successfully fixed by a screw passing through the great trochanter and neck of the femur.

Ivory pegs are made 3 to 6 inches in length. With cancellous bone it is sometimes preferable to use a square peg, so that when driven into a round hole the bone grips it more firmly. Screws may be made of silver, steel, or various alloys, and care should be taken that they are of the same diameter the whole way up; otherwise the bone is likely to split (Fig. 12).

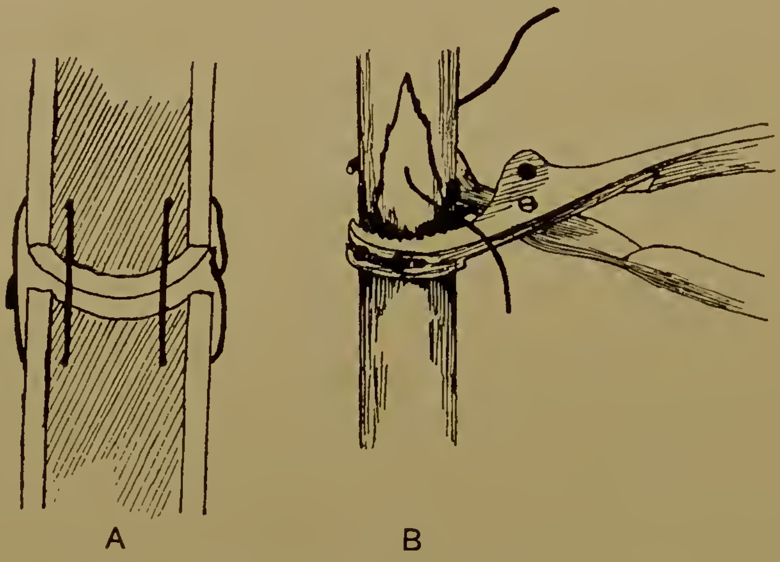

FIG. 11.—METHOD OF INSERTING WIRES.

A, In transverse fracture; B, in an oblique fracture, with use of Peters' forceps.

The fragment being held in accurate apposition to the rest of the bone, a hole is bored through it and well into the larger portion. A hand-drill is best for this purpose, as it is more readily controlled than one driven by electric power. If a screw is being used, a larger opening is made near the surface, so that the head may be sunk. The nail, peg, or screw, is now fixed into position either with a mallet or screwdriver. If an ivory peg be used, the projecting portion is cut off with a small saw. An ivory or ebony peg has also been fitted into the medulla of the fragments to act as an internal splint.[1]

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[1] *Trans. Roy. Med. Soc.*, December, 1908.

3. *Metal Plates.*—These are extremely useful in the case of a transverse fracture. They are made in the form of flat or curved plates of various sizes and shapes, so as to fit the outer sides of the two ends. Holes are present in these plates, through which screws can be passed and firmly fixed to the bone. In the case of transverse fractures of a long bone, two hemi-tubular plates may be used, one on either side, so that when the operation is completed the bone is encircled by a wide and firmly-fixed metal collar (Fig. 13). In applying them, the plate should be fastened to the fragment by a screw passing through one of the holes. The position of the rest of the holes can then be readily gauged. Lane[2] advises that the screws be only long enough to grip the compact bone—*i.e.*, $\frac{1}{2}$ to $\frac{5}{8}$ inch long—and threaded right up to the head (Fig. 12).

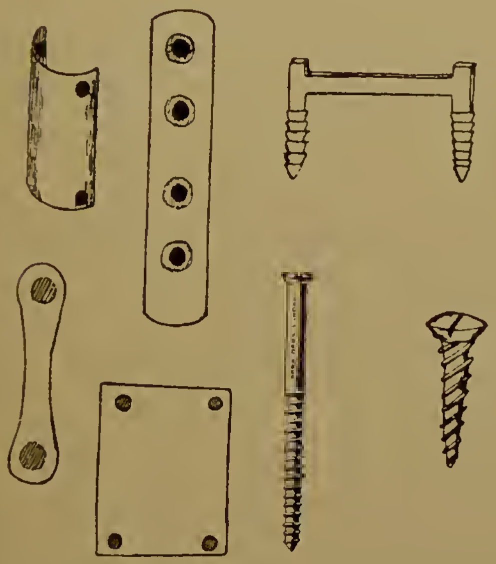

FIG. 12.—METAL PLATES, STAPLE, AND SCREWS.

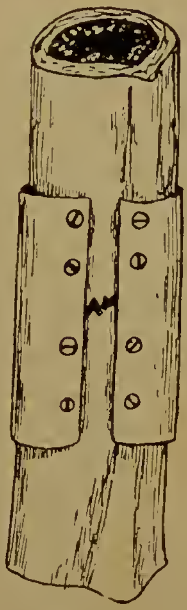

FIG. 13.—METAL PLATES IN POSITION TO FORM A COLLAR IN THE CASE OF A TRANSVERSE FRACTURE.

4. *Staples.*—These are the most uncertain of all the mechanical devices used, as they are extremely likely to

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[1] Binney, *Operative Surgery*, 1910, vol. ii., p. 100.
[2] *Annals of Surgery*, December, 1909, p. 1106.

work loose. They may, however, be used in some cases of transverse fracture, but even here they are unlikely to hold the ends firmly. They are often very valuable when the bone is too friable to take a wire or screw.

A hole is drilled in either fragment at such a distance that the staple will fit and then hold the fragments in good position. The staple is now driven firmly in by means of a steel rod, cupped at one end to fit the projecting parts of the staple, the rod being struck with a mallet.

All the above appliances should remain permanently embedded in the bone, but they not infrequently work loose and have to be removed.

5. *Clamps.*—Several forms of clamps have been used, which all, however, resemble one another in their action, which is to maintain the ends of the bone in firm apposition after deformity is reduced. When bony union is firm they are removed. It is claimed that by their use no foreign body is permanently left within the tissues, but there is the objection that the wound must in part be kept open for at least three or four weeks. Parkhill[1] uses an instrument consisting of several, three to four, silver-plated rods, which are firmly screwed into the fragments. These rods project through the wound, and to their outer ends are attached winged plates fixed by nuts. When the fragments are brought into good apposition, these plates are firmly fixed to one another by a clamp, so that the several rods form one unyielding whole and thus fix the fragments. The soft tissues are sutured round the bases of the rods, which are removed in from four to eight weeks. A somewhat similar but rather simpler apparatus is Stille's clamp (Fig. 14). Morison[2] uses a pair of strong forceps, the blades forming

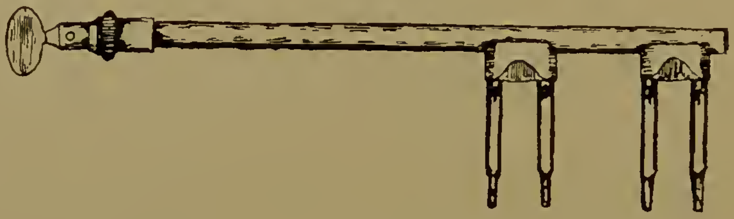

FIG. 14.—STILLE'S BONE CLAMP.

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[1] *Annals of Surgery*, May, 1898.
[2] *Ibid.*, December, 1909, p. 1114.

an oblong rim from which teeth project. The fragments are brought into apposition and gripped between the two blades, which are firmly closed and fixed by a catch in the handle. The outer parts of the handle are detachable, and are now taken off. The wound is sutured round the neck of the instrument. In six to eight weeks it is slightly opened up under an anæsthetic, and the blades removed.

CHAPTER III

COMPLICATIONS OF FRACTURES

Shock.

The amount of shock occurring in cases of fracture will be extremely variable. In young adults with a fracture due to indirect violence it is often negligible. Older people, those addicted to alcohol, or the poor and weakly, may suffer from it in a marked degree. In fractures due to direct violence, owing to the increased amount of injury to the soft tissues, and in cases of compound fracture, it may also be sufficient to demand treatment. It has been definitely shown[1] that in the majority of cases of shock the symptoms are due to exhaustion of the vasomotor centres from multiple afferent impulses, and therefore any stimulation of such centres will be bad treatment, in so far that at best it can but afford a temporary relief, which is followed by even further exhaustion.

In the case of simple fractures, however, there is no such exhaustion, and stimulative treatment—*i.e.*, the administration of alcohol or strychnine—is often of great benefit. If the fracture be compound or associated with much injury to the soft tissues—that is, where there is long-continued and severe pain, coupled perhaps with some septic infection—a condition of true shock with exhaustion of the vasomotor centres is present. This is well seen in cases of severe railway smashes, where several fractures may be present. Here no stimulants in any form should be given. The patient must be kept warm; ergot or pituitary extract[2] may be given subcutaneously, and continuous saline injections containing 1 drachm of suprarenal extract to the pint of saline given *per rectum* or intravenously, it being administered at the rate of 1 pint per hour. At the same time the foot of the bed may be raised to prevent the blood stagnating in the distended veins of the splanchnic area.

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[1] L. Mummery, *Lancet*, March 18, 1905, p. 696; Crile, *Surgical Shock*, 1897, and *Annals of Surgery*, vol. xxxv., 1902, p. 441; Walton, *Lancet*, July 4, 1908, p. 17.

[2] L. Mummery and Symes, *Brit. Med. Journ.*, September 19, 1908, p. 786; Oliver and Schafer, *Journ. of Physiol.*, vol. xviii., 1895, p. 277; Blair Bell, *Brit. Med. Journ.*, December 4, 1909.

DELIRIUM.

A condition of true alcoholic delirium is often seen in cases of fracture. This may occur, not in patients who have been consuming large quantities of alcohol within a day or two of the accident, but rather in the type of person who has been a steady drinker, daily consuming more than is good for him, yet rarely showing the signs of acute alcoholism, or perhaps only in a minor degree. In such patients the shock of the accident, coupled with the compulsory rest in bed, the absence of alcohol, and the complete change of habit, is often sufficient to give rise to a typical outbreak of alcoholic delirium. The onset of this may be delayed for two or three days, and may be gradual or rapid. Usually, on the second or third evening after the accident his attention begins to wander, and a slight delirium is present. By the next evening he becomes noisy and troublesome, continually attempting to leave his bed, and struggling with those in control of him.

If the patient is suspected of being of such a type, the onset of this state may be often prevented by the regular administration of alcohol in the form of beer or stout, 1 or 2 pints being given daily. In some cases it will be found that, if this fail, the patient may be readily controlled by persuasion ; and if a special nurse be told off to look after him, he may be kept in order until the condition passes off. In other instances he may be so noisy and restless that in hospital it is necessary to remove him to a secluded room. If the condition continue, and he be restless and sleepless, some form of narcotic may be necessary. Of these, the best and safest is undoubtedly a mixture of potassium bromide and chloral hydrate, gr. xxx. of each being administered four-hourly until sleep is induced. Veronal gr. vii. may also be given, but is less safe.

In such a patient delay in the process of union is common.

LUNG COMPLICATIONS.

In elderly people purulent bronchitis passing on to broncho-pneumonia is one of the commonest and most fatal complications of fracture. It generally occurs in those who are kept to their beds, and is then most marked in the lower lobes, being partially due to the fact that whilst on their backs such patients have great difficulty in emptying the smaller bronchi by coughing, and partly from the fact that their vascular system is in a poor state, and thus congestion and engorgement of these parts is very apt to occur. The condition, therefore, is often known as "hypostatic pneumonia," and so prone are elderly people to suffer from this complication that it is often necessary to relinquish all other methods of treatment in order to save them from this fate. By some means or other they must be kept upright, or, better still, walking about. Thus, in cases of fracture of the upper part of the femur, it is often necessary to provide some form of ambulatory treatment at the expense of good union.

The methods which may be adopted to gain this end will be discussed in a future chapter. Should any bronchitis be present, the patient should be kept warm and well protected; care must be given to the circulatory system, and a stimulant expectorant administered, strychnine being generally found to be the most efficacious. This may be well combined with some drug which will decrease the secretion, such as belladonna. Great care should be exercised in the choice of such drugs as carbonate of ammonia, ipecacuanha, squills, or senega, as these will probably increase the secretion and make the condition worse.

FAT EMBOLISM.

This condition is more common with fractures than with any other form of trauma. It is probable that to a slight degree it occurs in every case, but in only a few to a degree sufficient to give rise to symptoms. First described by Zenker,[1] microscopical examination has since frequently led to its discovery in such cases. For its occurrence it is requisite that there be sufficient force to drive the liquid fat into a ruptured vessel. These conditions are well found in all fractured bones. The liquid fat is present in the cancellous bone and medulla, the vessels are ruptured, and the walls are kept apart by the bony structure surrounding them, while a certain amount of force is always present.

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[1] *Beit. z. norm. u. path. Anat. d. Lunge*, Dresden, 1862.

The fat passing into the blood-stream in the form of globules is arrested in the lungs, and infarction is thus caused. If extensive enough to lead to rapid death, local changes may not have had sufficient time to have arisen, and the condition only be found if carefully sought for. Microscopic examination will then reveal the presence of many capillaries blocked with globules and cylinders of oil, which are too viscous to pass onwards. In other cases, infarction similar in nature to that arising from any other cause may be present. In some cases free fat may be visible in the blood in the form of droplets. In the slighter cases the fat may be gradually saponified and absorbed, and the condition of the lung then resolve. If the amount be large or the force of the circulation sufficient, a certain portion of the fat may pass through the lung capillaries and enter the systemic circulation, only to be arrested later in some other viscus, especially the brain.

Symptoms.—It is only in the more severe cases that any symptoms are produced, and it is extremely rare for the diagnosis of fat embolism to be made, although it is possible that many of the cases of delirium regarded as due to alcoholism are in reality dependent upon this cause. The symptoms are generally respiratory in character, and often do not appear until a considerable time after the accident. The respirations are quickened; there is dyspnœa, soon followed by cough and the expectoration of blood-stained sputum, the patient being at the same time remarkably collapsed. After a short time there is generally œdema of the lung, so that the dyspnœa is increased, and crepitations may be evident over the whole thorax. If these are sufficiently slight for the patient to recover, the signs of pneumonia will develop, the distribution of the consolidation being irregular.

When the emboli pass through the lungs and lodge in the brain, cerebral symptoms will make their appearance. These will begin with delirium, vomiting, and convulsions. If severe, this condition passes on to coma, or more rarely gives rise to localizing signs. The pulse is small and irregular, and coma may deepen until death occurs.

Rarely oil globules are found in the urine, but it is doubtful if this be due to renal embolism.

Treatment.—As far as possible this will be preventative, and for this reason the part should always be immobilized as soon as possible. If symptoms develop, the limb must be absolutely fixed, and massage and passive movements desisted from, so that further absorption shall be limited. Special care will have to be taken with regard to this if the patient be delirious. For the condition itself symptomatic treatment can be alone carried out. Collapse will call for the administration of stimulants, such as strychnine hypodermically, gr. $\frac{1}{60}$ four-hourly, brandy, and ether. If there be much dyspnœa, oxygen may be administered, preferably after having been passed through hot water in a Woolf's bottle.

Resulting œdema of the lungs and pneumonia must be dealt with along the lines already indicated.

COMPOUND FRACTURES.

A fracture is compound when there is a wound of the skin and superficial structures directly communicating with the ends of the bones. Such a condition may be caused either by direct violence, when the superficial structures are destroyed or lacerated by the force of the exciting cause, or by indirect violence, when the sharp end of one or other of the fragments is forced through the skin.

The greater number of these fractures are found in the labouring classes, as they are exposed to greater violence. They are then often severe, and the wound is very prone to be infected, either with the material with which the patient is at the time working, or from portions of his clothes lying on or in the wound. A wound of this type, often greatly lacerated, and already severely infected, is extremely difficult to cleanse, and in spite of every attempt the great majority of them suppurate, although this suppuration is often localized. In some cases it may spread up the intermuscular and fascial planes, and require further operation, or even amputation. In other cases, fortunately much rarer, septicæmia may take place, or even gangrene of the limb occur. Every effort, then, must be made to cleanse these wounds, the surgeon always aiming at obtaining healing by first intention, although but seldom succeeding.

The patient should be anæsthetized, the wound lightly plugged with gauze, and the surrounding skin shaved and thoroughly cleansed. For this purpose soap and water, turpentine, ether, and biniodide of mercury in spirit $\frac{1}{500}$, may be used. The limb is now surrounded with some form of packing, and protected from neighbouring structures with sterile towels.

The gauze in the wound being removed, all portions of dead or severely lacerated tissues, such as muscle and tendon, are taken away, together with any pieces of loose bone and foreign material. The tissues must now be thoroughly cleansed, the wound being enlarged if necessary, in order to gain free access to the deeper parts. If any of the soft parts, such as muscle, skin, or subcutaneous tissue, have any foreign material visibly ground into them, it is better to remove with scissors or scalpel the infected portions, until healthy-looking structures are reached. All bleeding-points are clamped, and the wound washed out with antiseptics. Of these, carbolic acid seems to be the most valuable; solutions of biniodide of mercury in spirit appear to have much less penetrative power. The ends of the bone may be shut off from the soft tissues with gauze plugs, and then touched all over with pure carbolic acid, the rest of the wound being thoroughly washed out with carbolic acid solution (1 in 20); in practice this will not be found too strong. The question will now arise as to whether the ends of the bones should be wired or otherwise mechanically fixed together. Wherever possible, it is best in this class of case not to do so. Such a wound cannot be absolutely disinfected, but the infection may be so small that the tissues are able to overcome it. If, however, they are irritated by the presence of a foreign body, they will be less able to do this, and suppuration is more likely to ensue. If, however, the position is bad, and recurs after reduction, there is no other alternative, and the ends must be fixed together. Divided soft tissues are now united—nerves with simple catgut; muscles, tendons and aponeurosis, with chromicized gut. The depths of the wound must be freely drained with a tube, and, if necessary, a counter-incision made. The skin is sutured and dressed, and a splint applied. If quite healthy and all discharge has ceased, the tube may be removed at the end of two days: but it is better to err on the side of leaving it in too long rather than to remove it too soon.

If the wound show subsequent local suppuration, and daily dressing be required, some form of aseptic and readily removable splint should be used. The ordinary wooden splints may in some cases be satisfactory, if the site of the splint does not correspond with that of the wound. Thus, if there be a compound fracture of the tibia, with the wound in front, a posterior wooden splint may still be used. In such cases the splint is firmly fixed by straps above and below the wound, the part of the splint opposite the wound being covered with mackintosh. By this means the dressing may be easily changed without disturbing the splint and the fixation of the fragments. Under other conditions a most useful splint is that made from aluminium-bars, having at short intervals slots placed, into which other portions of aluminium may be fixed to form crossbars. This material is readily cut and bent, and thus two bars may be cut of suitable length, and moulded to form antero-posterior or lateral splints to the limb, and then firmly united by the smaller crossbars placed at suitable positions and intervals. Fig. 5, B, p. 25, readily explains this splint.

It is of great benefit in that the bars may be moulded to fit any part of the limb, and they may be united in any position, so that the wound may always be free from the splint. Thus, in the leg, if the wound is posterior, an anterior bar may be used, with loops passing round below and above. The limb is then suspended by the bar, so that the wound itself is free from pressure. If it be of such an extent that one bar must be over it, the metal may at this spot be so bowed out as to lie 2 to 3 inches away from the surface of the wound.

Here may be considered the question of early or primary amputation of a limb which is the seat of a severe compound fracture. The mere presence of serious damage to the bone is seldom by itself sufficient to call for amputation, for, provided that the soft tissues are in good condition, extensive comminuted fractures will generally recover, and good union take place. Even if there be much laceration of the soft tissues, it is preferable to save the limb wherever possible. The amount of recovery that will take place in such cases is often remarkable. This specially applies to compound fractures of the finger, and the practice of early amputation, which is so often carried out here, is much to be deprecated, as recovery may often take place. It must be remembered that a limb may show much deformity after such an injury, and yet be preferable to an artificial one. Moreover, if at a later date, when healing has partly or completely occurred, it be found that the preserved limb is not only useless, but an encumbrance to the patient, it may then be removed. A patient may, indeed, urgently request such a secondary operation in severe injuries to the fingers where bony ankylosis of one of the joints has taken place, as his work may be thus interfered with; but not only can this operation be then readily performed, but the amount which has to be removed is generally much less than would be the case in primary amputation, for here the surgeon has to go relatively high up in order to avoid damaged tissues which later recover, and to escape sepsis of his amputation wound. In any case, such sepsis, owing to the proximity of the infected wound and the damage to the tissues, is very difficult to avoid, so that primary amputations are often followed by painful, irregular stumps, in marked contradistinction to the soft, supple, and painless variety following a secondary operation. Of course, if the whole of the soft tissues are reduced to a pulp, if there be great injury to the vessels, if the tissues are so ground up with foreign material that cleansing is impossible, if the limb be merely hanging by a band, and if gangrene be present or imminent, amputation may be essential. In all other cases primary amputation should rarely be performed. Fingers should very seldom be removed, but every attempt made to render them aseptic, to obtain healing as far as possible, and, if necessary, do a secondary amputation later.

INVOLVEMENT OF JOINTS.

A fracture in the neighbourhood of a joint may so involve the bone that the joint is entered, the fracture then being partly extra-articular and partly intra-articular; or the portion of the bone separated may lie wholly within the joint cavity, as in some cases of fracture of the upper end of the femur. In either case, if the joint be near the surface, it will be much swollen from extravasation of blood, and from the accompanying traumatic synovitis, whilst the other signs and symptoms of fracture may be present. In joints situated farther from the surface, the symptoms of a fracture will be much less marked, and an accurate diagnosis may be dependent upon a radiograph, which should in all these cases be taken. Owing to the fact that one fragment is often small and may show much displacement, either from the original trauma or from the pull of attached muscles, replacement and control may be difficult. Accurate apposition may also be made impossible from the fact that a portion of aponeurosis or synovial membrane is often turned in between the fragments, whilst the presence of blood-clot within the joint demands treatment by early movements to prevent the formation of adhesions between the articular surfaces. For these reasons the results of the ordinary methods of treatment are often poor, and therefore, if there be any difficulty in controlling the ends sufficiently to maintain apposition and to allow of early massage and passive movements, it will generally be found preferable to do some open operation, whereby the clot may be removed from the joint, the structures between the fragments readily extracted, and the ends brought into accurate apposition, and so fixed by wiring or other mechanical devices that passive movements and massage may be undertaken at an early date. A good example of the beneficial results following such a line of treatment is seen in the case of fracture of the patella from muscular violence.

Dislocation of a Neighbouring Joint.

Not uncommonly a combination of a fracture and a dislocation of a neighbouring joint is seen. Thus, in the case of a subcoracoid dislocation of the humerus, a fracture of this bone may also be present, perhaps the commonest type of this being a fracture through the greater tuberosity, although the shaft of the bone may be broken in the neighbourhood of the surgical neck. This latter type—*i.e.*, where the fracture runs through the shaft of the bone—is the more important, in that it gives rise to greater difficulty in treatment. Past experience has shown that either the dislocation or the fracture is very prone to be overlooked, and for this reason, and also because the joint may be involved, all fractures in the neighbourhood of joints should, if possible, be radiographed. As a rule, the nearer the fracture is to the joint, the more difficult is the diagnosis. If situated farther off, as, for instance, a fracture of the shaft of the ulna associated with forward dislocation of the head of the radius, the diagnosis is not usually difficult. In the same way, the difficulties in treatment are much more marked if the fracture is close to the affected joint.

In some cases the signs and symptoms are mainly those of the fracture; in others the dislocation is the more evident. This question will, however, be considered further with the individual varieties. When the condition has been diagnosed, attempts should first be made to reduce the dislocation. Possibly, in a few cases in old people or those suffering from other severe injuries, it may be preferable to leave the dislocation, and to treat the fracture alone, but such are few. An anæsthetic should be given, and attempts made to reduce the dislocation by manipulation, which, however, often fail. It is sometimes advised that the fractures be put up in splints, and that attempts be then made to reduce the dislocation, it being claimed that by this means the dislocated fragment is more readily controlled; but this is so seldom the case that it is hardly worthy of a trial. Attempts at reduction by means of extension should, of course, not be tried, owing to the presence of the fracture. If the dislocation cannot be reduced, operative treatment should be resorted to. In no case must success be readily accepted, and it is always best, after reduction appears to be accomplished, to have a second radiograph taken, so that no doubt on this point can exist. The patient should never be put into splints with the idea of obtaining union of the fracture, and, after this has taken place, attempting reduction of the dislocation by manipulation. This is almost certain to fail, for it is practically impossible to get such apposition of the fragments that union will readily occur; and even if it does, the changes in the joint will be so marked that open operation will be necessary to reduce the dislocation.

If open operation be decided upon, one of several methods may be attempted: either the fracture may be cut down upon, the fragments fixed mechanically, and the dislocated one then reduced; or the displaced fragment be first gripped with forceps and reduced, the two ends being then wired; or the joint may be cut down upon, the dislocation overcome, and the condition then treated as though a simple fracture were alone present. If the fracture be near the joint, a single incision may lay bare both injuries, and a combination of the two methods be then carried out. If the loose fragment be small, sometimes it is best to remove it entirely, but with improvement in the methods of fixation, and the more general use of early passive movements, such cases are becoming more rare. The choice of one of the above methods will depend upon the variety of the fracture and dislocation.

INJURIES OF VESSELS.

Large arteries or veins may be injured at the time of the accident from the nature of the violence if direct, or from the ends of the bones if indirect; or this may occur later from movements of the fragments, if these are not kept at rest, or during the attempts at reposition. In some instances, which are now fortunately rare, injury to the vessels, with occlusion and gangrene, may be caused from the pressure of the splints or bandages. It is probable that secondary muscular changes, such as Volkmann's contraction, are caused by a slighter degree of such pressure. Involvement of vessels in callus is apparently rare, but it may possibly be commoner than is known, only, owing to its slow development, sufficient time is given for the other vessels to dilate, and hence no symptoms are produced.

If the vessels be injured in a compound fracture, there will be severe hæmorrhage of an arterial or venous nature, which, being easily recognized, is generally temporarily controlled. If, however, the fracture be simple, a condition badly described as a "traumatic aneurysm" may develop. If the vessel be large, the exudate of blood will be diffuse and infiltrate the surrounding tissues; the patient will complain of increasing pain in the limb, and perhaps coldness of its extremity. If the extravasation of blood be profuse, he may even be collapsed. When the limb is examined, it is seen to be swollen to an amount varying with the looseness of the tissues at the site. The swelling may be soft and fluctuating or tense and hard, and perhaps even at this early stage some of the blood may have penetrated close to the surface, so that the limb is discoloured. The part below is pale, anæmic, and cold, while pulsation may be absent from its vessels. Unless the condition be speedily relieved, complete occlusion of the artery and vein from the pressure of the extravasated blood is likely to take place, and gangrene of the limb to set in. If the injured vessel be smaller, the extravasated blood may be less in amount, and may remain localized. In this case the surrounding connective tissue will become condensed, so that a sac containing fluid is formed. If a communication with the vessel persist, a pulsating swelling simulating an ordinary aneurysm, and known as a "localized traumatic aneurysm," may be formed. This will as a rule, however, not make itself evident until a later date, and should then be treated on the same surgical lines as a spontaneous aneurysm.

In the case of a compound fracture, the vessel, if small, should be ligatured, and the previously described methods of dealing with this type of fracture carried out. If the fracture be simple, attempts must be made to accurately localize the site of injury to the vessel. The most important factor in arriving at this conclusion is undoubtedly the recognition of the site of the fracture, the amount of extravasation being of no value as a guide, as the blood may travel some distance before forming a large collection, according to the nature of the tissues into which the hæmorrhage takes place.

The bleeding-point must now be cut down upon, and the nature of the injured vessel determined. If small, ligature of both ends is the best treatment. If, however, it be the main artery or vein of the limb, attempts to suture the rent or to do an end-to-end anastomosis should always be made, a fine round needle and silk sutures being used, according to the methods advocated by Carrel,[1] the walls being everted by interrupted or continuous mattress sutures, so as to bring the two opposite layers of intima into contact, or the proximal end invaginated into the distal, as advised by Murphy.[1] The same treatment will apply to injuries of the main vessels in cases of compound fracture. Should these means fail, the ends should be ligatured, it being important to remember that both ends should be tied, owing to the freedom of collateral circulation which often exists. The hæmorrhage having been successfully controlled by one or other of these means, attention is turned to the soft tissues, and as far as possible all blood and clot are removed. The tissues being laid open, it is now better mechanically to fix the ends of the bones in apposition, either by wiring or by the use of Lane's plates. A small drainage-tube having been inserted, the rest of the wound is closed and a splint applied. If all oozing has ceased, the tube may be removed at the end of two to three days. It is generally unwise to attempt it before then.

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[1] *Surg. Gyn. and Obstet.*, ii., 1906, p. 266; and *Johns Hopkins Hosp. Bull.*, xviii., January, 1907.

INJURIES OF NERVES.

At the time of the injury or shortly afterwards a nerve may be partially or completely divided, or, owing to the trauma, loss of function without anatomical division may be present. Later on the nerve, if lying close to the bone, may be involved in callus, so that a more slowly developing physiological or even anatomical division may take place. The commonest site of such a condition is the shaft of the humerus, the musculo-spiral nerve being included in callus as it winds round the bone, or directly injured by the sharp ends of the bone. If the division be primary—*i.e.*, directly due to the injury—symptoms will date from the time of the accident; but if it be purely physiological, they will usually clear up within a short time, and will not be extensive. In the case of complete division there will be loss of epicritic (light touch and minor degrees of heat and cold—22°-38° C.) and protopathic (extremes of heat and cold) sensation in the area supplied by the nerve, as shown by Sherren.[2] The epicritic loss is very constant, while the protopathic is variable, but always less than the epicritic. There will be immediate paralysis of the muscles supplied.

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[1] *New York Med. Rec.*, January 16, 1897.

[2] *Injuries of Nerves, and their Treatment*, London, 1908.

In cases of incomplete division, on the other hand, the symptoms may be slight, or may be so extensive that a diagnosis between the two conditions is impossible at the time of the accident.

It is therefore very important that a correct method of investigation be carried out. If there be complete loss of epicritic sensation over the sole area of supply of the nerve, and if there be definite protopathic loss with paralysis of the muscles supplied, the lesion is either one of complete anatomical or physiological division, or of an extensive incomplete division: an accurate diagnosis cannot be made between these conditions at the time.

By about fourteen days after the injury the electrical reactions of the muscles will be sufficient to lead to a decision. If there be complete anatomical division, the affected muscles will give no reaction to faradism, and a slow, wavelike contraction to the make and break of the constant current, instead of the brisk contraction of the normal muscle, whilst a stronger current will be required to elicit it. There may also be polar reversion.

If the division be incomplete, there may be no alteration in the electrical reactions, or the "reaction typical of incomplete division" may be present (Sherren). A contraction of the affected muscles is caused by the make and break of a weaker constant current than that required on the sound side. The contraction is brisk when compared with that seen when the reaction of degeneration is present and polar reversion is absent. The muscles do not respond to the interrupted current.

In slighter cases of incomplete division there may be well-marked sensory changes with no motor alterations, or the sensory changes may even be incomplete.

When the injury is secondary—*i.e.*, due to the pressure of callus or splints—the symptoms will develop at a later date. If the limb has not been examined before putting on the splints, some difficulty may arise; but if external pressure be the cause, such cases are more commonly incomplete, or if complete are associated with a pressure sore.

If the nerve be involved in the callus, the symptoms will develop late and will be slow in onset. In the case of a mixed nerve, the patient will complain of severe and constant pain in the area of sensory supply, passing on to anæsthesia, and paralysis will gradually develop, the muscles later giving the reaction of degeneration to electrical stimulation.

Treatment.—If the fracture be compound and there are symptoms of complete epicritic loss, protopathic loss, and paralysis, the wound must be carefully investigated while it is being disinfected and the nerve found and examined. If divided, the ends must be cleansed, any lacerated portion removed, and union brought about by careful approximation with catgut sutures. If the fracture be simple, the lesion to the nerve may be anatomical or physiological. The former is, however, so much the more probable that an operation should always be undertaken at once (Sherren[1]). If left until the diagnosis is more certain, as shown by the electrical reactions, the prognosis will not be nearly so good; while if open operation shows no anatomical lesion, no harm will be done. The ends of the nerve must be isolated, freshened, and sutured with catgut, and the fragments of the bone mechanically fixed. Splintage to relax the muscles, and daily massage, must be continued until recovery is complete. According to Sherren, this, in cases of primary suture, will take for epicritic recovery twelve to eighteen months; for protopathic recovery, four to twelve months; and for motor recovery, about one year. These figures are approximate only. Motor recovery depends upon the distance of the injury from the muscle.

If secondary and incomplete, the condition must be carefully watched, splintage and massage being used. If constant or progressive, operation will be required. In the case of secondary involvement, as soon as the diagnosis is definite, as shown by a gradual increase in the symptoms, an operation should be undertaken. Evidence of complete division should never be waited for, for if the nerve be involved in callus it must be freed, and the earlier this is undertaken the better will be the prognosis. The ends of the nerves outside the callus should be found, and the new bone gradually removed from around it. As much callus as possible is removed to prevent recurrence, and the nerve is wrapped in Cargile membrane and replaced. If division be complete, some form of plastic operation to bring about union of its ends may be necessary. The bone should never be shortened for this purpose unless an ununited fracture be present.

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[1] *Loc. cit.*, pp. 82, 83.

The after-treatment will be the same as in the primary cases, but recovery is slower.

MALUNION.

By malunion is meant fixation of the two portions of the bone in some abnormal manner, such abnormality being sufficient to cause symptoms. As already mentioned, it is seldom that perfect apposition of the ends of the bones is obtained, but in the majority of cases the deformity is so slight that no symptoms are caused, and the part becomes functionally normal. In some, however, the alteration in shape may be so marked that the affected limb is not only visibly deformed, but functionally imperfect.

The malunion may take the form of an exaggerated overlapping, and consequent marked shortening, as in the case shown in Fig. 2, B, p. 17, where some 3 to 4 inches shortening would have resulted; or the bones may be firmly united at an angle, and the resulting deformity be even more marked. A good example of such a condition is seen in some cases of transverse fracture of the lower end of the humerus, the resulting deformity limiting the flexion of the forearm. It may also occur in the case of the femur, tibia, or ulna (Fig. 15). Occasionally the deformity is a rotatory one; thus, a neglected fracture of the femur may result in the lower portion uniting with the upper in a position of eversion.

Perhaps the most important variety of this type of deformity is that of some fractures of the upper part of the radius. Here the hand may have been put up in a position midway between pronation and supination, whilst the upper part is fully supinated, subsequent supination of the hand being thereby greatly limited.

Yet a fourth variety of malunion is that in which fusion between two parallel bones takes place. This is seen most markedly in fractures of both bones of the forearm at the same level, in which all four ends may be firmly fixed together in a mass of callus, giving rise to a condition known as "cross-union." In this case there will, of course, be complete abolition of all movements of pronation and supination.

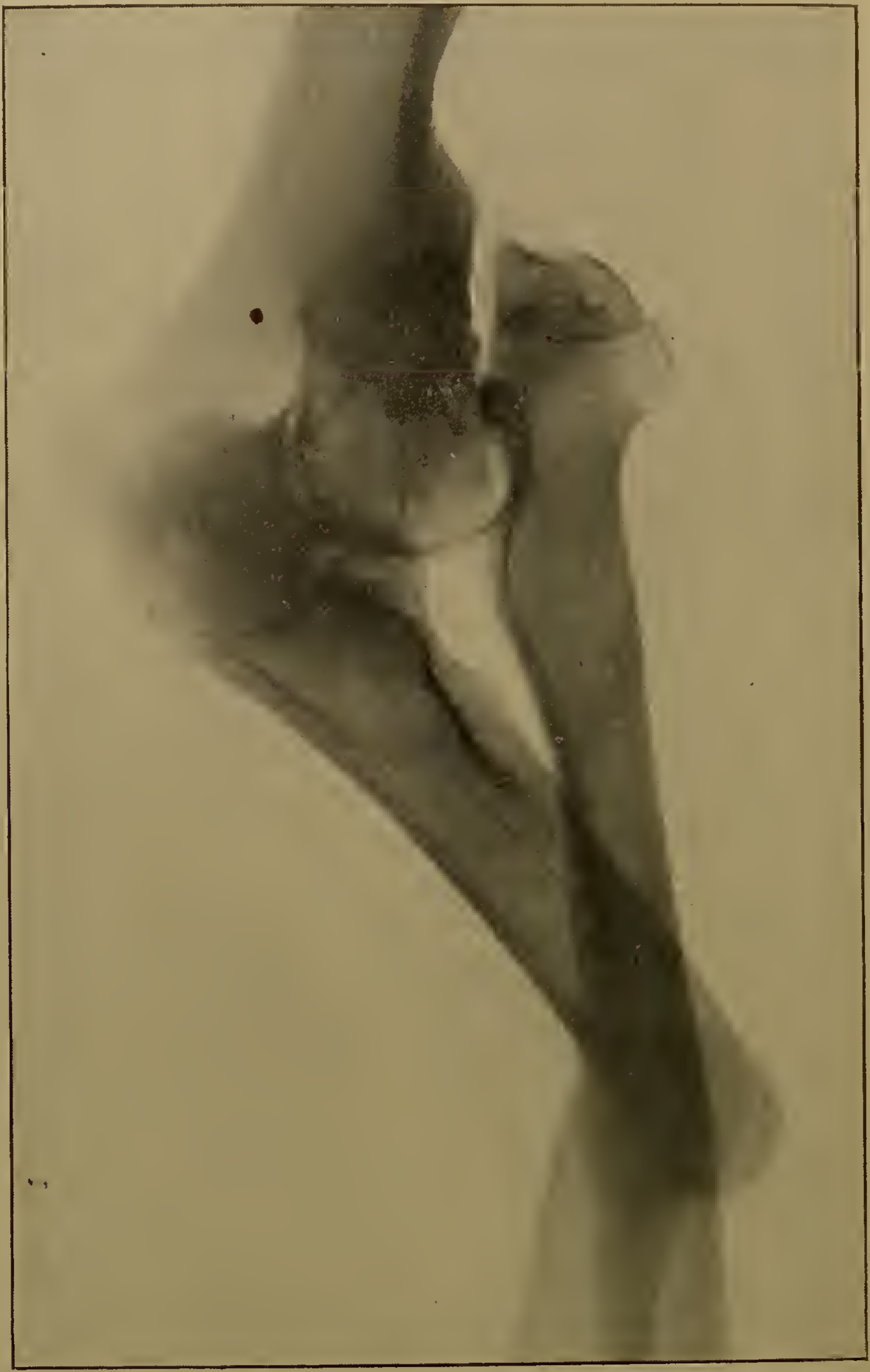

FIG. 15.—ANGULAR MALUNION OF ULNA OF TEN YEARS' STANDING. (Mr. Openshaw's Case.)

This was successfully treated by open operation.

The treatment of malunion will largely depend upon the type and amount of deformity, as well as upon the length of time it has existed. After many years operation becomes extremely difficult, for all the surrounding muscles and tendons may have undergone marked contraction, even if they are not involved in the callus, so that in some cases tenotomy may be required in order to get the ends into position after they are freed.

When the deformity is one of only slight shortening, the tendency to operate will not be so marked. Thus, if a patient have 1 to 1½ inches shortening of the femur from overlapping, and no other symptoms are present, it will generally be advisable to provide him with a high boot rather than to attempt osteotomy, with subsequent reduction, especially if it be of old standing.

Angular deformity is the condition which most often calls for operative interference. If this be so marked that the patient's work is interfered with, or if discomfort is present, open operation should be advised. The site of the fracture having been definitely determined, a free incision should be made and the bone bared. Simple division of the bone is now performed with a chisel, either transversely or obliquely; the latter gives surfaces more suitable for firm fixation, but at the expense of shortening. The limb may now be straightened, and if easily maintained in this position by means of a splint, it will be unnecessary to mechanically fix the fragments. If, however, there be the slightest difficulty in maintaining the correct position, the ends may be fixed with Lane's plates, screws, or wires. In some cases it may be possible to divide the bone with a chisel through a small opening in the soft tissues, in the same manner that a Macewen's osteotomy is performed. Unless the fracture be quite recent, no attempt at manual osteoclasis should ever be made. This method, of considerable risk at any time, is unjustifiable in these cases, as the site of the fracture is generally the strongest part of the bone, and fracture may therefore occur at some undesired and unlooked-for position.

Rotatory deformity, especially in the forearm, may often call for operative treatment, as it may seriously limit the movements of the arm. These cases are often extremely difficult to deal with. A free incision should be made over the fracture, and the bone divided with a chisel or Gigli's saw. As far as possible this division should be transverse, so that subsequent fixation is more readily accomplished. The distal part of the arm is now fully supinated, so as to come into position with the proximal, and mechanically fixed in that position. If the condition of the fragments is good, the best method of securing them is undoubtedly a wire mattress suture passing through both ends. If this cannot be carried out, metal plates with screws may be used. In many such cases it is extremely difficult to obtain good fixation in the correct position owing to a certain amount of secondary contraction of the muscles. This may be largely prevented by adopting the procedure advocated by Lane[1]—viz., a preliminary course of massage whereby they are made more pliable. In the after-treatment massage should be commenced as soon as the wound has healed, and passive movements in about two weeks.

When there is cross-union of two parallel bones, open operation will be the only method of overcoming the deformity. A free incision is made in the position which will give best access to the bones. The soft tissues having been retracted, an attempt should be made to divide the union between the two bones without disturbing their continuity. Such will only be possible when the bone is well formed, and is even then unlikely to succeed, owing to the irregular positions of the fragments. Failing this, all four fragments are separated, the excess of callus removed, and the appropriate ends securely fixed with wires or plates. The tendency to reunion may be prevented by stitching a portion of aponeurosis, or even of muscle, between the two bones.

Passive movements and gentle massage must be commenced as soon as possible.

UNUNITED FRACTURES.

In many instances union does not take place within the expected time; but these should not all be regarded as cases of non-union, for if treatment be continued for a few weeks the majority will undergo firm fixation, although movement between the two ends may be obtained as late as ten to twelve weeks after the accident.

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[1] *Brit. Med. Journ.*, May 4, 1907.

The three following forms of non-union are described:

1. *Fibrous Union.*—This is probably the most common type. In it the mass of inflammatory material around the ends of the bone has remained a simple granulation tissue, no proliferation of the bone cells having taken place. It is dependent upon some depressed state of the bone, which may be part of a general disease or consequent upon the accident itself. Thus, certain constitutional states, such as alcoholism, syphilis, or the presence of any specific disease, will greatly prevent the proper formation of new bone. Locally, death of the surrounding bone, such as may occur in comminuted fractures, where the blood-supply of the fragments is cut off, and the fragments themselves are too large to obtain nourishment from the surrounding lymph, will act in the same way. Severe sepsis may cause death of the bone by cutting off the blood-supply. The most common factor is probably, however, undue separation of the fragments, especially by the interposition of a portion of muscle, tendon, or aponeurosis, between the ends. Excessive movement will also prevent union.

In such cases the ends of the bone are embedded in a mass of scar tissue, the amount of which may be very variable, and is in part dependent upon the degree of separation of the fragments. This tissue may be very firm, and prevent further displacement of the ends, which are usually rounded and enlarged, showing to a slight degree attempts to form new bone. In fact, in many cases, especially where non-union is not dependent upon any disease of the bone, the amount of surrounding callus may be large.

2. *Pseudarthrosis.*—In this condition, which is almost certainly dependent upon excessive movement of the fragments, the ends have become rounded off, the surface bone is condensed, and even a partial or complete cap of cartilage may be present. The surrounding connective tissue is much thickened, and becomes lined by a smooth membrane, similar to that found in adventitious bursæ. In the cavity thus formed fluid may be secreted, so that the condition may come to closely resemble a true joint.

3. *Absolute Non-Union.*—This is much more rare than the above varieties. In it no attempt whatever has been made

at union, the amount of fibrous tissue between the ends is so small as to be negligible, and the ends of the bones, instead of being enlarged and rounded, may be atrophic and pointed.

Such a condition is probably due to a decreased vitality of the tissues, and is thus found more commonly in the aged and infirm, or in those whose health has been undermined by previous ill-health or evil habits.

Treatment.—At the present day the treatment will to a large extent be preventative. Thus, if good apposition cannot be obtained, and there is reason to believe that adventitious structures are placed between the ends, open operation will be undertaken and the difficulty overcome.

In the early stages the treatment should simply aim at stimulating the formation of new bone, for, as already stated, many of these cases are merely ones of delayed union. The limb may thus be placed in an accurately fitting divided plaster, so that while this is worn absolute fixation is obtained. Regular massage to increase the vitality of the part should also be prescribed. If the affected limb be a leg, the patient may be allowed to get about with the aid of crutches or a wheel-chair, so that his general nutrition will not suffer. At the same time his health should be carefully attended to with the aid of drugs and diet. If no improvement accrue with these means, Bier's method of passive hyperæmia may be tried. An elastic bandage is applied firmly above the seat of fracture, at first for periods of two hours, being omitted for intervals of six hours. The time during which the bandage is in position is gradually increased, until it is six hours on and six hours off. It should be as tight as the patient can bear without suffering any pain. The presence of pain is an indication that it is too tight.

If it be certain that there is non-union, and not simply delayed union—*i.e.*, after about six months have elapsed—further treatment should be tried. If the ends are in good position, attempts to stimulate the bone at the site of fracture may be made. The most successful method is that of grinding the two ends firmly together for a short period, and then securely fixing them in some form of splint or plaster. If this fail or the fragments are not in good apposition, an open operation should always be done. The ends are freely laid bare, and all fibrous tissue or other adventitious material carefully removed from the fractured surfaces; in fact, it is usually better to remove also a thin layer of bone, so as to gain two entirely fresh surfaces. These portions of bone may be removed somewhat obliquely, so that the two ends may be the more readily fixed; but, as already pointed out, such a method produces some shortening. They are then held firmly in position by means of plates and screws, or wires, care being taken to see that no rotatory deformity exists after this has been performed. In some cases even this method may fail, and attempts to secure firm union have been made by bone-grafting, often with very successful results.

Much discussion has arisen as to whence this bone should be taken. It may be of human origin, or removed from one of the lower animals. Several instances of good results have been recorded where the bone was taken from an animal of a species far removed from man. Thus, Sir Watson Cheyne[1] records a successful case of grafting a portion of a rabbit's femur, together with the periosteum, to form a new bridge to a nose. He advises[2] that the bone should be obtained from a young dog in cases where there is failure to reproduce the shaft of a bone, but he states that "unfortunately, in a good many cases, absorption goes on to such an extent that the limb becomes weak again, but in some cases very satisfactory results have been obtained."

Lane[3] has recorded two cases, one of congenital absence of part of the ulna, and the other of loss of the shaft of the same bone, where good results followed grafting of a rabbit's femur. Later,[4] however, he states that he has given it up for two reasons: one, the danger of sarcoma developing about the foreign bone—a condition which actually occurred in one of his two cases; and the other, that the new bone did not increase in thickness, and was not usually strong enough to perform the function expected of it.

In spite of the good results recorded above, there is no doubt that failures after this method are numerous, and on

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[1] *Clin. Soc. Trans.*, 1899, vol. xxiii., p. 218.
[2] *Manual of Surgical Treatment*, part iii., p. 180.
[3] *Clin. Soc. Trans.*, vol. xxxii., p. 44.
[4] *Operative Treatment of Fractures*, p. 132.

a priori grounds it would not be expected that material taken from an animal of a species so far removed from man as a rabbit or dog could ever become incorporated into the human tissues; and it may well be that, even where good results appear to follow, much of the benefit is due to the graft acting as a stimulant and initiating the growth of new bone.

Much better results seem to have followed the grafting of human bone. Sir William Macewen[1] reports a case where there was complete necrosis of the humerus of a boy, with no new formation of bone. A groove was made in the muscles between the ends of the bone, and the space thus formed was filled with portions of bone removed from several cases of cuneiform osteotomy, the bone being cut up into small pieces. Much benefit resulted, and thirty years later[2] he was satisfactorily performing the duties of an engineer's pattern-maker. This surgeon's work showing that new bone can undoubtedly grow from a pre-existing portion of bone free from periosteum has already been alluded to (p. 16).

Rushton Parker[3] has used this method of transplanting bone as advocated by Sir W. Macewen, in cases of non-union of the humerus and ulna, with excellent results, the bone in these cases being obtained from the surrounding callus.

Lexer[4] has even recorded cases where large portions of bone, and in some instances whole joints, have been successfully transplanted.

From these results it would seem better wherever possible to use human grafts.

Whichever method is used, the graft must be removed with every aseptic precaution, preferably by an assistant at the same time that the surgeon is operating on the patient. This operation must also be conducted with extra precaution as to asepsis. If the case be one of non-union, the graft is best cut up into small pieces and placed between the ends of the bone, these if necessary being fixed in position with a wire. If a larger portion of the bone be absent, so that the ends are widely separated, a larger graft may be used. The wound having been carefully sutured, the limb is absolutely immobilized on a splint of suitable form.

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[1] *Annals of Surgery*, vol. vi., No. 4, p. 301.

[2] *Ibid.*, December, 1909, p. 959 *et seq.*

[3] *Trans. Roy. Med. Soc.*, July, 1908.

[4] *Med. Klin.*, May 31, 1908.

Volkmann's Ischæmic Contraction.

This is a condition of contraction and fibrosis of the muscles which may follow after fractures. It was first described by Volkmann in 1869.[1]

It is much more common in the upper extremity than the lower. Thus, Thomas[2] has collected all the cases he could find recorded in the literature—107 in all—and of these 105 occurred in the muscles of the forearm. It is more common in the young.

It is generally regarded as being due to the faulty application of splints, but many cases are recorded where this factor has but little or no bearing. Harris[3] considers that it may arise in one of two ways: either rapidly—perhaps within twelve hours—apparently from the very tight application of a bandage; or more slowly—perhaps only after several weeks—from a moderately tightly applied bandage.

Usually within a short time of the application of a splint or bandage, applied for some fracture of the forearm or humerus, but sometimes for a more distant injury, such as a fracture of the clavicle, the patient complains of pain in the hand. On examination this is found to be somewhat swollen, and may show venous engorgement. If the splints or bandage be left in position, or even in spite of their immediate removal, a certain amount of swelling of the muscles of the forearm occurs, this being chiefly confined to the flexors. Shortly after this the muscles gradually begin to stiffen and contract, so that the fingers are rigidly bent, the muscles feeling hard and contracted although they are often quite small and visibly atrophied.

That the fixation of the fingers is due to muscle and tendon shortening is shown by the fact that whereas when the wrist is straight the fingers cannot be extended, yet as soon as the wrist is bent on the forearm the flexors are relaxed, and the fingers may then readily be straightened. In advanced cases, evidently due to the faulty application of splints and bandages, pressure sores may be present on the limb. The hand may show trophic changes, such as blisters or ulcers, and the circulation of the affected limb is often poor. As Harris and Thomas have both shown in their papers, this condition may often be associated with a nerve lesion, and this factor must never be overlooked. The same pressure which has so seriously affected the muscles may have led to injury of one of the nerves, or these structures may have been involved in callus at the site of fracture. A careful examination for any sensory changes in all cases of ischæmic contraction will generally prevent this condition being overlooked.

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[1] Pitka u. Billroth's *Chirurgie Krankheiten der Bewegungsorgane Erlangen*, 1869, Bd. ii., S. 846.

[2] *Annals of Surgery*, March, 1909, p. 330.

[3] *Brit. Med. Journ.*, August 15, 1908.

Thomas (*loc. supra cit.*) found evidence of nerve involvement in 61 out of his 107 cases.

The condition if left untreated is steadily progressive; the muscles become smaller and more and more contracted, so that the fingers are bent down into the palm, and the hand is flexed on the forearm to such an extent that the limb in time is quite useless. The affected muscles, even in quite late stages, show the normal reactions to electrical stimulation, thus showing definitely that the change is not dependent upon any nerve lesion.

Examination of the affected muscles always shows a marked increase of the fibrous tissue, and in many cases which have been operated upon they are seen to be bound down in, and adherent to, a mass of scar tissue. There has been, however, much difference of opinion as to how this condition arises. Many surgeons have attempted to reproduce it experimentally. The best-known experiments are those of Leser, Losen, and Hildebrand; but in every case either gangrene or a flaccid paralysis was produced, and in no case the contractions so characteristic of this disease. Others have described changes in the nerves, and have regarded the contractions as due to some primary change here; but the electrical reactions show that this suggestion is unlikely. Thomas, in his summary of the descriptions of the conditions found by various writers, shows that in nearly all cases the muscle fibres, and especially the nuclei, showed degenerative changes, these latter often being replaced by granular material. Later the nuclei and then the muscle fibres disappear entirely, being replaced by fibrous tissue.

Cases have been reported where the condition followed some occlusion of the artery, but experimental ligature of a vessel has never been followed by this change. Volkmann himself stated that the condition might be seen after ligation, rupture, and contusion of bloodvessels, but the ischæmia was not complete, and thus gangrene did not occur. In many cases there are alterations in the pulse.

The probable pathology therefore is that the circulation to the muscles is diminished, in the majority of cases, by pressure, but not entirely cut off, this diminution of blood-supply being followed by degenerative changes in the muscle fibres and nuclei, which are gradually replaced by a contracting fibrous tissue.

The treatment will, as far as possible, be preventative. Every case that has had a bandage or splint applied should be examined not later than twenty-four hours afterwards, and if any signs of pressure are seen all bandages must be loosened. The splints must always be carefully padded, and no pressure made over bony points. The systematic use of early massage and passive movements has done much to lessen the incidence of this disease.

If once present, the condition is extremely difficult to treat with any hope of success. When the fibrous tissue has made its appearance in the muscle structure, it is almost impossible to restore again the contractile and elastic power of that muscle. Jones[1] advocates gradual extension of the affected fingers by means of small zinc splints applied to them. They must be first extended by flexing the wrist. The fingers being thus fixed, regular movements of the wrist are begun until extension is gradually increased; longer splints are now applied, and the movements continued until gradually full extension is obtained. He reports several good results.

Systematic massage and passive movements may be of value, but the improvement is usually very slow.

Volkmann advocated forcible stretching of the contracted muscles under an anæsthetic, but the results here are poor, the muscle soon contracting again. In severe cases it is usually necessary to perform some operation upon the tendons in order to lengthen them, and by this means preserve the contractile power still remaining. This was apparently first performed in England by Page,[1] while two successful cases were reported by H. L. Barnard[2] one year later.

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[1] *Liverpool Medico-Chirurg. Journ.*, January, 1909, p. 110.

Resection of a portion of the bones in order to relatively lengthen the tendons has been carried out in several cases, but this is a much more clumsy method than tendon-lengthening. It leads to increased deformity and weakness of the extensors, and any abnormal adhesions which may be freed by tendon-lengthening are untouched.

No good results seem to follow the use of fibrolysin.

In some cases the deformity is so great and the reaction to treatment so poor that amputation may have to be performed. This should, however, only be undertaken as a last resource, and rather at the express desire of the patient.

Myositis Ossificans.

In some rare cases a local form of ossifying myositis may follow a fracture. The simplest expression of this condition is one where the amount of callus formation is extensive and involves the surrounding muscles. In other cases the muscles may, at some later date, begin to show calcareous deposits, which increase in size until the utility of the affected muscle may be seriously impaired. A similar condition may follow dislocations, in which case it is chiefly limited to the elbow-joint, the new bone being deposited in the brachialis anticus (Fig. 16). Such bony deposits may, however, occur in other muscles, but they are limited almost wholly to those which are situated close to the bone.

Grieg[3] has reported several cases occurring with dislocation of the elbow, and regards the new formation of bone as due to the escape of bone-forming cells into the surrounding muscle at the time of the injury.

The symptoms will be mainly those of mechanical limitation of movement from the presence of the new bone, associated with a certain amount of pain. If this limitation be sufficient to cause inconvenience, the new bone should be dissected out of the muscle by open operation.

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[1] *Lancet*, 1900, vol. i., p. 83.

[2] *Ibid.*, 1901, vol. i., p. 1138.

[3] *Edin. Med. Journ.*, October, 1908, p. 297.

SARCOMA.

Sarcoma is often stated to follow a fracture, it being apparently thought that the newly-formed callus is prone to take on malignant characters. The evidence of such change is, however, very slight. Many of the recorded cases have shown definite evidence of sarcoma within a few weeks or months of the fracture. With so short an interval, it is much more probable that the fracture was predisposed to by the presence of the sarcoma, and was, in fact, the first evidence of such a lesion. Bearing such a possibility in mind, it becomes remarkable how often these recorded cases show that the fracture followed very slight violence, nor must the fact that the fracture subsequently unites be regarded as evidence against the primary presence of new growth. In cases of definite sarcoma with spontaneous fracture, reunion is by no means uncommon, in spite of the fact that a large mass of growth may be present; and it is therefore quite possible that the same series of changes has taken place in many of the cases where the sarcoma was regarded as secondary to the fracture, the real sequence

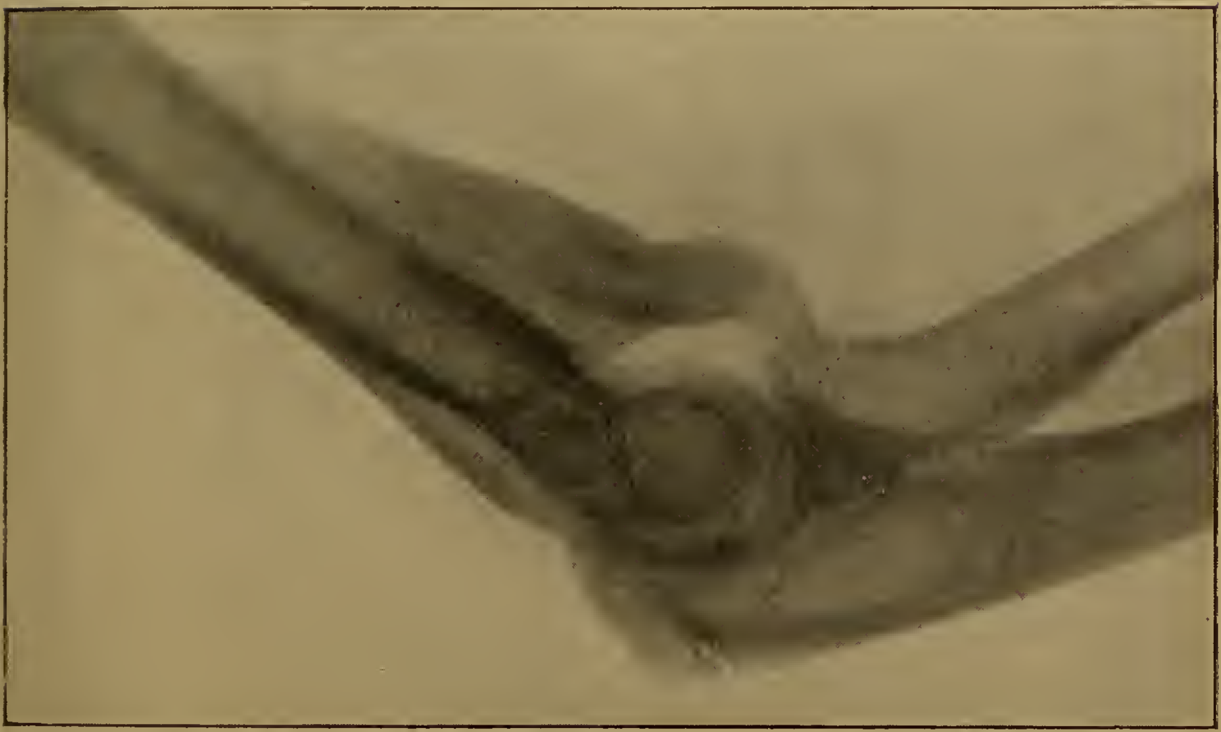

FIG. 16.—TRAUMATIC MYOSITIS OSSIFICANS. (Mr. Furnivall's Case.)
New bone in substance of brachialis anticus after injury to elbow.

being the presence of new growth, spontaneous or nearly spontaneous fracture, reunion, and later fresh evidence—such as the formation of a tumour—of the presence of sarcoma.

That a history of trauma is common enough in cases of sarcoma of bone will be generally admitted. Coley[1] states that in 615 such cases a history of injury was present in upwards of one-third. But in all cases of new growth in any situation there is always a tendency for the patient to ascribe the condition to some previous trauma, which may have been very slight or only a mere coincidence, so that, before such cases are accepted as definite, it will be necessary to show that a considerable period existed between the time of the fracture and the onset of symptoms of new growth, or to have definite evidence that no new growth was present at the time of the fracture.

To throw light upon this question, all cases of sarcoma of bone admitted to the London Hospital in the ten years 1900-1909 inclusive were investigated, with the following results:

TABLE III.

	Total.	Following Injury.	With Fracture.
Jaw - - - -	49	1	0
Femur - - - -	28	3	3
Pelvis - - - -	18	1 (?)	0
Skull - - - -	16	1	0
Humerus - - -	12	6	5
Foot - - - -	12	2	0
Tibia - - - -	9	2	1
Fibula - - - -	8	0	0
Scapula - - - -	5	0	0
Ribs and sternum - -	4	0	0
Ulna - - - -	3	0	0
Nose - - - -	2	0	0
Radius - - - -	1	0	0
Clavicle - - - -	1	0	1
Vertebra - - -	1	0	0
Totals - -	169	16	10

Of the 16 cases giving a history of previous injury, it was in 6 either so remote in position or occurred so long before the onset of symptoms that no relationship can be recognized between the two. In the other 10 cases (5·9 per cent.), the new growth followed soon after the injury, but, as in the case of other tumours, great caution must be exercised before regarding the new growth as in any way dependent upon the injury.

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[1] *Annals of Surgery*, March, 1907.

Of the 10 cases of fracture, 8 were definitely spontaneous or due to very slight injury, other signs of sarcoma being present before the fracture in most of them; that is to say, in these 8 cases the fracture must be regarded as definitely due to the growth. In the other 2 (1·2 per cent.), the tumour apparently followed the fracture. In 1 there was a fracture of the great trochanter of the femur of three years' standing, apparently only in part united, before sarcoma appeared. In the other there was a fracture of the lower third of the shaft of the humerus due to direct violence; this remained ununited for twelve months, and was then followed by sarcoma.

This percentage is, however, so low that these two cases may be mere coincidences, and the above figures seem to show that sarcoma cannot be considered as a definite complication of fractures.

Two of the cases of spontaneous fracture united perfectly before the limb was amputated—one after two months, and one after three weeks.

CHAPTER IV

FRACTURES OF NASAL, SUPERIOR MAXILLARY, MALAR, AND HYOID BONES

Nasal Bones.—Fractures of the nasal bones are nearly always due to direct violence, and may be of one of two types—

(*a*) Lateral displacement.
(*b*) Flattening of the nose.

In either case the injury to the nasal bones is usually associated with a fracture of the cartilaginous septum, whilst the cribriform or vertical plates of the ethmoid, the vomer, or the nasal processes of the superior maxillary bones, may also be injured. The majority are compound, in that either the mucous membrane or skin is perforated. Thus, septic complications may ensue, and, if localized, lead to destruction of cartilage or bone. If the cribiform plate of the ethmoid be injured, this sepsis may proceed to a fatal meningitis.

Lateral Displacement.—This type of fracture is more commonly due to blows upon the side of the nose or to those upon the tip. The two nasal bones are either fractured or separated from their insertions into the frontal and superior maxillary bones, the whole nose being then displaced to one side. They may be separated from the vertical plate of the ethmoid, or this may be fractured. In either case the quadrilateral cartilage is usually torn in a horizontal direction, the antero-inferior portion being carried with the nasal bones. This may be associated with a certain amount of depression of the upper ends of the nasal below the frontal bones. Such a condition is very closely simulated by a displacement of the lateral cartilages of the nose, but here the nasal bones proper maintain their normal positions.

The displaced nasal bones may be impacted, and thus considerable difficulty in their replacement arise. The symptoms are extreme pain at the time of the accident, generally coupled with nasal hæmorrhage. The patient may notice that the nose is displaced to one or other side, and that pressure or attempts at movement are associated with distinct crepitus, which may be harsh in character, due to the bones grating, or softer, from movement of the fractured portions of the cartilage.

The deformity is very marked, and if the fracture involves the cartilage the columnella and the tip of the nose will also be displaced, whilst if the septum is intact they will maintain their normal positions. If the fracture be compound into the nasal cavity, surgical emphysema of the nose, face, and eyelids, may rarely be present.

It is essential that the condition be treated, for not only is the deformity very marked, but, if the septum be involved, unilateral, or even bilateral, obstruction may persist. If unimpacted, no difficulty will usually be encountered in replacing the bones. If impacted, or if the deformity has existed for a few days, this will be much more difficult, and the administration of an anæsthetic will be requisite. In either case, after the nose has been readjusted it is important to see that the septum is in correct position; if not, the deformity here must be overcome. This is best accomplished by direct manipulation with a pair of narrow-bladed sequestrum forceps, the blades of which are carefully protected with a piece of rubber tubing.

In many cases, when reduction is once properly accomplished, no retentive apparatus is required, but if the parts do not remain in position some form of splint must be used. Pieces of strapping are often applied over the bridge of the nose on to the face, but they usually fail to fix the fragments, and, indeed, it is difficult to understand why they should. Without doubt, in these cases the best splint is that advised by Scudder,[1] and known as "Cobb's splint." It consists of a band securely fixed round the head; from the anterior portion of this a bar and pad projects downwards. This bar and pad is hinged, so that lateral pressure may be exerted upon the nose. When in correct position it may be fixed by a screw on the headpiece.

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[1] *The Treatment of Fractures*, 1907, p. 58.

As a rule nasal irrigation is unnecessary, but if there be any discharge or continued hæmorrhage, an alkaline and mildly antiseptic douch should be ordered.

The following[1] will be found useful:

℞ Sod. bicarb.	gr. xv.
Sod. biborat.	gr. xv.
Ac. carbol.	gr. iv.
Glycerini	♏xlv.
Aq.	ad ℥i.

To be mixed with double the quantity of warm water.

Flattening of the Nose.—This type of fracture is due to direct blows upon the bridge of the nose. One or both of the nasal bones are broken away from their attachments to the nasal process of the superior maxillary bones, and flattened out so as to override these processes. In such cases the vertical plate of the ethmoid is generally fractured. This fracture may be vertical, and run through to the quadrilateral cartilage. More commonly, however, it is horizontal or oblique. This type is more likely to be associated with fracture of the cribriform plate of the ethmoid, whilst the lateral portions of the bone are more prone to injure the nasal processes of the superior maxillary bones.

The symptoms in such cases will be much the same as in the first variety; the deformity, however, is very different. The upper part of the bridge, corresponding to the nasal bones, is flattened, so that, seen from the front, this portion of the nose simply appears somewhat wider than usual. When seen from the side the depression is very marked, and is limited to the upper part, the tip of the nose still maintaining its normal prominence. The transition from the sunken to the elevated parts is often very sharp, so that the tip of the nose appears to be tilted. Crepitus may or may not be obtained. As in the last variety, surgical emphysema, increased on forcibly blowing the nose, may be present. In some of these cases the displaced nasal bone may fracture the nasal processes of the superior maxillary bone, and lead to sufficient injury of the nasal ducts to obstruct them, so that epiphora results. Such a complication is, however, rare.

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[1] Lack, *Manual of Surgical Treatment*, Cheyne and Burghard, part v., p. 282.

The treatment of this variety presents considerably more difficulty than the last. It should always be attempted as soon as possible, for even after a few days sufficient fusion may have occurred to make reposition difficult.

A general anæsthetic will usually be required, and the nasal cavity is then carefully examined, any displacement of the septum is seen, and attempts are made to overcome this with the same instrument used in the last case. This, aided by carefully-applied lateral pressure on the nasal bones from without, will often be sufficient to elevate the depressed part. If it fail, the depressed nasal bones should be raised by pressure from within. For this purpose any long, narrow instrument may be used as an elevator; the probe-pointed end of a Watson Cheyne's dissector (Fig. 17) will be found as useful as any. The fingers of the other hand should be used at the same time to manipulate the bones in position from without. When they are replaced, it is generally found that the correct position is well maintained, and thus no retentive apparatus will be required. In other cases they almost immediately fall back. To prevent this some form of permanent pressure from within is usually applied. In the case of fractures high up, the upper portions of the nasal cavities in front are carefully but firmly packed with gauze, preferably oiled, so that it may the more readily be removed. This is extremely uncomfortable, but is generally the most efficient method. The gauze should always be removed at the end of two days. At the end of that time the tendency for the bones to slip back may have been overcome. If not, fresh gauze may be applied, but it should always be changed at this time, lest

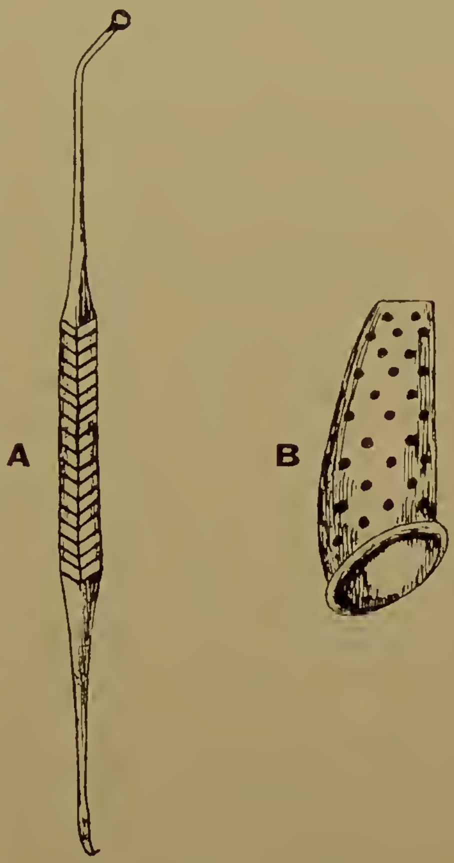

FIG. 17.
A, Watson Cheyne's dissector; B, Asch's vulcanite tube.

sepsis occur. Any difficulty in removing the gauze may generally be overcome by syringeing the nose with a weak alkaline solution.

If the fracture be low down, an Asch vulcanite tube (Fig. 17) may be inserted into the nostril, and will usually be found to maintain the bones in good position. In cases of severe crushes one of these may be required up either nostril, the nasal bones being moulded into position over them.

Whenever there has been much internal manipulation, or where foreign bodies are placed in the nasal cavities, gentle irrigation with a lotion, such as that advised on p. 76, should be ordered to be used twice a day.

Ouston[1] advises that in cases with marked depression a tenotome be introduced through the side of the nose at the site of the depressed nasal cartilages, dividing their attachments to the maxillæ. The knife is pushed through to the septum, and this divided longitudinally at the level of the posterior borders of the lateral cartilages, and the separation continued until the whole of the depressed portion of the nose can be easily lifted by the tenotome transfixing the nose. The nasal bones are then transfixed by a long pin driven through them with a mallet, and another passed in a similar way through the cartilages. Strips of gauze are wound round the two pins in a figure of eight, and the arch thus supported. In later cases he used screw caps on the pins to prevent pressure sores, which the gauze was likely to cause.

Superior Maxillary Bones.—Fractures may be limited to one or involve both superior maxillary bones. They are generally caused by a fall on the face, the patient being either pitched out of a cart or off a horse or bicycle. This last accident is so common a cause that Scudder[2] speaks of this fracture as the "bicycle accident." The fracture is usually irregular; the alveolar margin may be partly or completely separated, and the front wall of the antrum driven in.

The corresponding side of the face is often considerably depressed, and the superior maxilla crumpled up. In some cases the two superior maxillary bones may be torn from their bony attachments, so that the front of the face is freely movable, the palate moving with the upper jaw. The line of separation is then usually situated in front of the malar bones, which maintain their normal attachments. Two such cases are reported by Bligh,[1] both of which were caused by a throw from a cart, the patient striking the ground with the front of the face. In such cases there is but little bony deformity, the bones falling back readily into their normal positions, but being freely movable. Fractures of the nasal processes associated with separation or fracture of the nasal bones have already been considered. They may lead to temporary or permanent occlusion of the nasal ducts, with epiphora.

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[1] *Brit. Med. Journ.*, September 26, 1908.

[2] *The Treatment of Fractures*, 1907.

Fracture of the anterior wall of the antrum may be associated with fracture and displacement of the malar bone, this latter being forcibly driven down and impacted into the anterior surface of the superior maxilla. Any variety may be associated with fracture of the orbital plate.

The signs and symptoms will vary with the type of fracture, and, being so often dependent upon direct violence, these fractures are often compound. Either the skin of the face is lacerated, or there is a tear of the mucous membrane in the superior fornix beneath the upper lip. If the anterior wall has suffered much, the alveolus and part of the palate may be driven in, so that considerable depression of the face is caused. There will be much local swelling and bruising, marked tenderness on pressure or attempts to bite, and perhaps bleeding from the affected side of the nose, the mucous membrane of either the nasal or orbital cavities having been lacerated. The fragments may be movable, this movement being accompanied by crepitus.

The most marked deformity is seen in those cases where the malar bone is driven down. Here the whole side of the face may be flattened. Where the superior maxillary bones are separated there may be much pain and swelling, the bones are felt to be freely movable, and crepitus is readily obtained. There is, however, but little deformity. Fractures of the nasal process may be accompanied with surgical emphysema and epiphora.

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[1] *Lancet*, May 15, 1909.

The infra-orbital nerve may be implicated in those fractures which involve the anterior wall or the orbital plate. The nerve may be completely divided, so that immediate anæsthesia results, or later it may be involved in callus, giving rise to neuralgia in its area of distribution.

If the violence has been severe the injury may have extended upwards, and led to a fractured base, which is recognized from the presence of cerebral symptoms. In such cases sepsis spreading to the meninges has to be carefully guarded against.

Treatment.—If the superior maxillary bone be completely detached, with but little deformity, it is only necessary to immobilize the fragments. Any wounds are carefully cleansed, and sutured, if possible, by an intradermic suture, so that little or no scar results. Any slightly displaced teeth are replaced and the mouth cleansed. The movable portion of the face is generally best kept in position by bands of adhesive strapping. The mouth and nose must be kept carefully clean by regular syringeing, at first about every three or four hours, later twice a day. Under this line of treatment all swelling of the face as a rule rapidly decreases.

At first the patient must be fed entirely on fluids, so as to prevent any pressure upon the movable parts. At the end of seven to ten days a slop diet may be ordered, but solid food must not be allowed until the end of four to six weeks, by which time firm union has usually occurred, but even then it should not be given unless there is no tenderness on pressure.

A fracture of the nasal process alone will require no treatment.

If there be considerable displacement with an accidental wound, this latter must be thoroughly cleansed, and attempts made to replace the separated portions through it. This may be aided by the careful use of a pair of sequestrum forceps, having the blades protected with rubber tubing. At the same time counter-pressure is made on the outer side. The wound is again cleansed, any loose chips of bone removed, and the edges of the skin then sutured together. After this the case is treated on the same lines as those showing but little displacement.

If there be no wound, attempts should be made to overcome any deformity by external pressure and manipulation. If these fail, the question will arise as to whether any open operation should be done. If the displacement be but slight, and more especially if the alveolar margin be unaltered, it it better not to undertake operative measures, as firm union is almost certain to occur. If, however, the deformity be very marked, as in cases where the malar bone is driven into the antrum, some open operation should be undertaken.

The patient being anæsthetized, the upper lip on the affected side is retracted, and an incision made into the superior fornix. With the aid of a pair of sequestrum forceps or a raspatory, it may now be possible to replace the bones. If still unsuccessful, the antrum may be opened in its lower part, and the depressed portions raised by the use of an elevator inserted into the antrum. When once disimpacted and pushed forward, they may be readily replaced by pressure in the right direction exerted over the face. When this is performed, a drainage-tube should be inserted into the antrum, so that it may be regularly irrigated.

If the portions of the bone tend to fall back, the antrum may be carefully packed with gauze, so as to retain them in position. This should, however, be avoided wherever possible.

If the deformity be in the alveolar margin, apposition may be obtained by closing the jaw and binding the lower jaw against the upper, whereby the lower teeth act as a splint.

The after-treatment will be similar to that of the first-mentioned varieties, but if there be much facial damage it may at times be necessary to feed the patient through a nasal tube.

In rare cases subsequent neuralgia may necessitate an operation to free the infra-orbital nerve.

The Malar Bone.—Fractures of this bone are unusual. They are generally caused by severe direct violence, and thus may be seen in policemen who have been kicked in the face while struggling with refractory prisoners. They occasionally occur during boxing. As a general rule the injury affects one of the processes of the bone, so that it is displaced as a whole. Fracture of the bone itself is very rare, and must not be confounded with a congenital fissure, existing in some cases where the bone is developed from two centres—the so-called "os Japonicum." The bone may be driven downwards and inwards, and mention has already been made of those cases where it is impacted into the anterior surface of the superior maxillary bone. It may be driven downwards, and perhaps a little backwards, in which case it may interfere with the coronoid process, and thus limit the movements of the lower jaw.

The most constant symptoms and signs are the presence of pain and bruising, with perhaps an open wound and the characteristic deformity. If well defined there is a marked depression to the outer side of, and just below, the eye, whilst the upper part of the cheek may show a marked prominence. Smaller degrees of deformity are best determined by standing behind the patient and carefully palpating the malar bones from this position. Alterations in the position of the bone are then easily estimated by comparison with the sound side. In some cases subconjunctival hæmorrhages may be present.

If the injury be recent, attempts should be made to replace the bone by pressure and manipulation. For this purpose an anæsthetic should be given, and pressure then applied from below either in an anterior or posterior direction, according to its position. As a rule this method will fail, but if there be no marked disability it is better to advise the patient to put up with the deformity, as it can only be reduced by an open operation which is very likely to leave a visible scar. If, however, there be limitation of movement in the lower jaw from displacement of the malar bone backwards, or if the deformity be so great that the patient is anxious to have something further done, an operation may be undertaken to replace the bone. This should be done at as early a date as possible before union has occurred.

A small incision is made, preferably at a higher level than the bone, and a blunt hook then passed downwards over the lower edge and pulled upwards, by which means the bone can usually be replaced, or a narrow elevator may be used to prise it back into position. These movements are assisted by pressure applied from below. The wound is now carefully sutured, preferably with an intradermic suture.

When once the bone is back in position there is no tendency for its further displacement, and for this reason no retentive apparatus will be required.

The Hyoid Bone.—Fracture of this bone is rare, but may result from direct violence, such as attempts at throttling, or after attempted suicide by hanging. The greater cornua may be separated from the body, or the body itself fractured. There is swelling and bruising of the front of the neck, while the patient complains of great pain, increased on attempts to swallow, on speaking, and with all movements of the floor of the mouth. Very rarely the fracture may be compound, in which case sepsis leading to dyspnœa is likely to follow at a later date.

If there be any deformity, this should be overcome by manipulation. If this present difficulty, an anæsthetic should be administered, when, with one finger in the pharynx aided by external manipulation, it can generally be overcome and the fragments placed in position.

The application of a poroplastic collar is then usual, but it is unlikely to be of much value.

If the pain be great in spite of this treatment, many surgeons advise that the fragments be wired; but this is very difficult, and the danger of sepsis is considerable. In some cases there will be sufficient hæmorrhage, with swelling and pain, to demand rectal feeding for two to three days. If the hæmorrhage still continue, a transverse incision should be made down to the bone, the bleeding-point ligatured, and the fragments mechanically fixed.

The presence of pus will also demand an incision and free drainage. If there be much associated œdema, tracheotomy may be necessary.

CHAPTER V

FRACTURES OF THE INFERIOR MAXILLA

FRACTURES of the inferior maxilla are not uncommon. They are nearly always due to direct violence, such as blows on the tip or side of the jaw, or falls with the chin striking the ground. The more common positions for fracture to take place are indicated in Fig. 18. The position will be determined partly by the direction and site of the blow, and partly upon the condition of the jaw; thus, if several teeth are absent, the bone will be weaker at this spot and more likely to yield here.

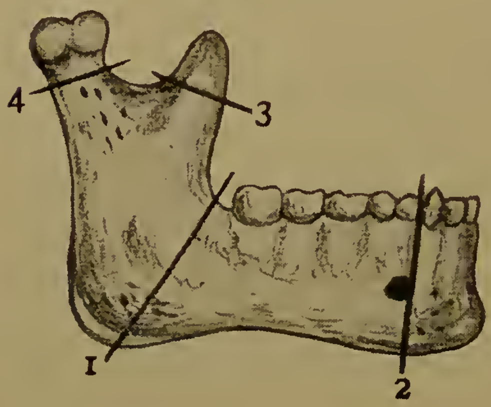

FIG. 18.—INFERIOR MAXILLA, SHOWING SITES OF FRACTURE.

1. **Through the Canine Fossa.**—At or near the canine fossa is the commonest site for a fracture to occur, for in this position the bone is narrowest, owing to the presence of the deep canine socket; whilst it is still further weakened by the presence of the mental foramen.

In some cases the lateral incisor is large, with a deep fang, in which case the fracture may take place here instead of at the canine fossa. The violence is nearly always delivered directly on the tip of the chin, so that the anterior part is driven downwards.

The fracture may be unilateral or bilateral, the latter being associated with the greater amount of displacement.

Since the inner side of the bone is only covered with muco-periosteum, this type of fracture is always compound; and as the people most exposed to violence of this nature usually suffer from a septic condition of the teeth and mouth, the fracture is very likely to become infected, and necrosis of small portions of the bone, with the formation of sequestra, is a common complication. Rarely, severe cases of alveolar abscess may be followed by advanced necrosis sufficient to lead to spontaneous fracture of the bone.

Symptoms.—The soft parts over the bone generally show signs of severe trauma, the lower lip may be lacerated, or only bruised and swollen, there is pain and tenderness on biting or pressure. Crepitus is usually easily elicited, and may be best sought for by passing the forefinger into the mouth and gripping the anterior part of the bone, together with the incisor teeth, between the finger inside the mouth and the thumb on the chin. By this means the anterior fragment may be easily moved on the posterior. Abnormal mobility of the anterior portion will often be well marked, especially if the fracture is bilateral.

The line of the teeth will be altered in greater or less degree, and this alteration in position may be overcome by movement of the fragment. One or more teeth may have been loosened or knocked out by the accident. The muco-periosteum of the gum at the site of the fracture is generally swollen. It may be visibly lacerated and bleeding.

Septic changes soon set in. At first there is only increased salivation, so that the saliva may dribble from the mouth; soon the face becomes more swollen, and the breath foul and offensive. If long neglected, septic absorption occurs, the neighbouring lymphatic glands become swollen and painful, the skin over the fracture perhaps red and œdematous, whilst pyrexia and general malaise may be present.

If suppuration take place, sinuses may form on the chin or in the neck.

In unilateral cases the amount of displacement will be small, and may consist only of a slight alteration in the line of the teeth. The posterior fragment is drawn upwards by the temporal masseter and internal pterygoid muscles until it comes in contact with, and is fixed by, the upper teeth. It is drawn slightly forward by the external pterygoid. The anterior portion tends to be drawn downwards and backwards by the digastric, mylo-hyoid, genio-hyoid, and genio-hyoglossus muscles; but being attached to the sound side the displacement is but slight. If, however, the fracture be bilateral, the displacement is much more marked, and the anterior fragment may be pulled downwards and backwards to a considerable degree.

Treatment.—The deformity may readily be overcome by fixing the posterior fragment against the upper teeth, and then bringing the anterior fragment upwards until it is in line with the posterior and also against the upper teeth. It may then be pushed backwards until it is firmly in contact with the posterior fragment. By this means the upper teeth are used as a splint, and perfect position obtained. The fragments may be fixed in this position by the use of a four-tailed bandage applied to the chin, the two lower tails being brought up in front of the ears and tied over the top of the head, whilst the two upper tails are carried round and knotted below the occiput, the two knots being further tied together to prevent slipping.

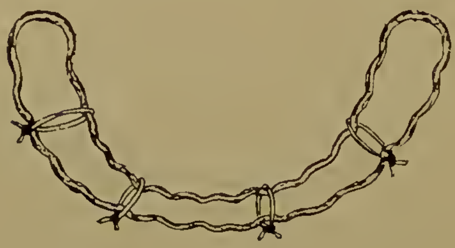

Fig. 19.—Dental Wire Splint.

This method, although easy to apply and keeping the fragments in very good position, is objectionable in that the mouth has to be kept firmly closed for from three to five weeks, so that eating and speaking, and more particularly cleansing of the mouth, are very difficult to carry out. For this reason, whenever possible, the surgeon should seek the co-operation of a good dentist, and some form of dental fixation apparatus should be fitted, the four-tailed bandage being used as a temporary measure.

Many forms of dental apparatus are used, but they may be grouped together in two classes.

(*a*) Dental wire splints. Here a frame of wire is made to run round all the teeth of the lower jaw in the form of a bent ellipse, the two ends being soldered together (Fig. 19). This frame is best made round a model of the teeth, the model being made of plaster of Paris, with the use of a dental modelling cup, in the same way that a model is taken by a dentist in fitting an artificial tooth-plate.

If the services of a good dentist cannot be obtained, it may be made on the patient with a piece of thin wire, which is removed and duplicated in stouter material. This wire frame should fit comfortably round the whole line of teeth close to the gums, and the inner and outer bars are then fixed together by cross-bands of thinner wire running between the teeth close to the gums, this usually requiring an anæsthetic.

By this means firm fixation is obtained and the mouth can be readily opened. It rather tends to increase oral sepsis, but if care be taken over this matter it is one of the most useful forms of splint. It should be maintained in position until union is firm, usually about four weeks.

The method of wiring together by a single loop of wire the teeth on either side of the fracture is not to be advocated, as these teeth, often already loosened by the initial trauma, are likely to be pulled from their sockets, and in any case firm fixation by this method is difficult to obtain.

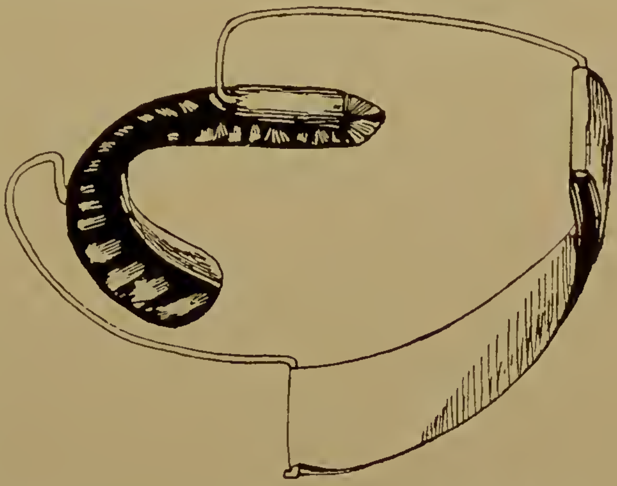

FIG. 20.—VULCANITE PLATE WITH RODS AND BANDS—KINGSLEY'S APPARATUS. (After Scudder.)

(*b*) Dental plates. These are made of hard rubber or vulcanite moulded to fit the teeth or gums in the same way as a tooth-plate. They may fit over the teeth or, if these are absent, over the alveolus. There are many forms. The simplest is that usually known as "Kingsley's apparatus," which consists of an accurately fitting cap from the anterior of which spring two wires which, leaving the angles of the mouth, pass round the outer sides of the cheek, and are fixed together by a strap running round the back of the head. When in use, the arms are bound down by a bandage passing beneath the chin (Fig. 20). In other forms the dental cap is made to press the jaw against a plate beneath the chin, as in Mata's splint, by means of clamps or rods outside the mouth. They should be kept in position for about four weeks, and only removed then if union be firm.

Rarely the above methods fail to obtain good apposition. In such cases it is necessary to wire the bone. The wires must be passed through the bone deep to the roots of the teeth, and to carry this out satisfactorily it is usually much preferable to make a small incision through the skin, even at the expense of an external scar. Attempts to wire from within the mouth are fraught with considerable difficulty.

Whatever method of fixation is chosen, great care must be used in the after-management, especially to prevent sepsis. For this reason, if an anæsthetic be given to apply the splint, any carious stumps should be removed at the same time.

The patient must carefully cleanse his teeth with a soft brush after every meal, as well as in the early morning and late evening. He must thoroughly wash out his mouth with an antiseptic solution at frequent intervals during the day. The following makes a reliable wash :

℞ Acid. carbol. - - - -	ʒi.
Sodii bicarb. - - - -	ʒi.
Aq. - - - - -	ad ℥vi.

Misce. ℥i. ex aqua ʒi.

A weak solution of peroxide of hydrogen or of potassium permanganate may be used.

Whilst the patient has the splint applied, only fluid or very soft food requiring no chewing movements should be administered, and for some weeks after its removal care must be taken not to bite any hard substances.

2. **Through the Angle.**—This type of fracture is much less common than the last-named. It may be produced by direct violence delivered upon the angle of the bone. Owing to the fact that this portion is covered and protected by the internal pterygoid, it is not usually compound. The upper limit of the fracture may, however, be sufficiently far forward to escape this muscle, in which case the muco-periosteum behind the last molar tooth may be lacerated, and the fracture thus become infected. It may be combined with a fracture through the canine fossa on the same side.

Symptoms.—There will be signs of local trauma, the angle of the jaw being bruised; deep tenderness will be well marked, and may be increased on attempts to bite. Owing to the fact that both the masseter and the internal pterygoid have a wide and firm aponeurotic attachment to the bone, there will be little or no displacement of the fragments, and thus the line of the teeth will not be much altered. Even in those cases where it is combined with a fracture at the canine fossa, the separated fragment will show but little displacement, as it has no muscular attachment. These fractures may lead to a good deal of difficulty in diagnosis, but by firmly gripping the anterior portion between the finger and thumb crepitus may be felt.

Treatment.—In those cases where there is no communication with the oral cavity, it is only necessary to protect the part from movements. For this purpose a four-tailed bandage should be applied, so as to keep the lower teeth in apposition with the upper.

After a week or ten days this bandage may be removed to allow the patient to eat; but, as in the last variety, only very soft or fluid food must be allowed for the first three weeks, and gradually added to as the strength of the union increases. It is wise to explain to the patient the condition of affairs, so that he may understand the danger of excessive movement when the bandage is removed.

Should the mucous membrane be ruptured and the fracture compound, the same careful methods must be taken to avoid sepsis as in the first variety. If necrosis occur and abscesses form, they should be opened early, so as to prevent them burrowing in the neck.

3. **Through the Coronoid Process.**—This is a very uncommon form of fracture. It may be produced by direct violence upon the side of the face when the mouth is wide open, and thus the coronoid process depressed below the level of the zygoma, or it may occur in association with fracture of the malar bone or zygoma. This latter bone having been first fractured, the coronoid process is separated by the same violence.

A compound comminuted fracture of this part may also be rarely met with. It is due either to punctured wounds or gunshot injuries.

With simple fractures there is, as a rule, but little displacement, owing to the wide attachment of the temporal muscle on the inner surface of the ramus of the jaw. Rarely, however, this tendinous attachment may be torn through, when the separated fragment will be pulled by the temporal muscle high up into the temporal or zygomatic fossa.

Symptoms.—There will be no displacement of the jaw. Movements of closing the mouth may be weakened and accompanied with pain, while local tenderness is present. If there be complete separation of the fragment, movements of forcible closure will be associated with increased bulging of the temporal muscle on the affected side, and the separated fragment may perhaps be felt in the lower part of the temporal fossa.

After a time this temporal muscle will atrophy, and lead to a certain amount of asymmetry of the face. If the fracture be compound, the separated fragment, or fragments, may be felt.

Treatment.—If there be no displacement the jaw should be supported, and the patient fed on a light diet, so that all biting movements are prevented. He should be warned of the danger of forcibly biting any hard substance, and should abstain from this for from four to six weeks after the injury.

If there be separation, it is probably always best to cut down and wire the fragments, as otherwise apposition cannot be obtained. It is often advised that no operative measure be undertaken, but early movements of the jaw encouraged. Such a method is, however, followed by considerable weakness, and by asymmetry of the face. In cutting down upon the fracture, care must be taken to avoid the branches of the facial nerve and Stenson's duct. The fragment, being seized in forceps, is drawn down. Holes are carefully drilled in it and in the ramus, the two being wired with thin silver wire. Passive movements may be started in about five days, but active movements should be prevented for three to four weeks, the patient wearing a four-tailed bandage. In cases of compound fracture the wound must be thoroughly cleansed, and the fragments, if comminuted, may be removed; but, wherever possible, the separated portions should be fixed to the ramus. If the fragments are removed, it is better to attempt to suture the tendon of the temporal muscle to the ramus of the jaw with a silk or kangaroo tendon suture, passed through a hole drilled in the bone, by which means a fresh attachment of the muscle may be gained.

The after-treatment, if there be no suppuration, will be that adopted after wiring a simple variety. If suppuration occur, the wound must be opened and freely drained.

4. **Of the Condyle.**—This is also a very rare fracture. It is produced either by severe direct violence over the condyle or by blows on the point of the jaw. In this case the condyle is driven backwards, and a fracture of its neck may occur. Rarely it may be driven upwards through the glenoid fossa into the middle fossa of the skull, when death usually occurs.

Symptoms.—There will be no displacement, but much local tenderness, and all movements of the jaw, especially those of opening and closing, will be accompanied by a painful grating sensation referred to the glenoid fossa. This pain may persist, or articular changes take place, of sufficient severity to lead to marked diminution of movement, or even ankylosis.

Treatment.—If left alone, union is very unlikely to occur, however carefully movements be prevented. Limitation of movement and pain are, however, such common sequelæ that some form of operative treatment will nearly always be called for.

Attempts to fix the two fragments are very unsatisfactory, the condyle being so small a fragment that this cannot be well carried out. Complete removal of the separated portion is the most successful method of treatment.

An incision about 1 inch in length is made just below and parallel with the zygoma. The posterior border of the masseter is pulled forward, or, if necessary, detached in part from the zygoma. The capsule of the joint is thus exposed, and may be best opened by a vertical incision. The fragment is found, and if fixation be thought impossible, it will be better to excise it at once. The neck of the bone is now carefully rounded with a chisel, so as to leave no sharp projecting portions. The interarticular cartilage should always be left. The capsule is now sutured with one or two stitches of catgut, and the wound closed without drainage. A dressing may be applied, with adhesive strapping or collodion, so that the jaw is unsupported. Passive and active movements are commenced at once, and continued until they are quite free and unassociated with pain.

CHAPTER VI

FRACTURES OF THE STERNUM AND RIBS

Sternum.—Fractures of the sternum are rare, and usually due to extreme violence. This may take the form of a severe blow upon the front of the chest, when the sternum is either fractured close to the sterno-manubrial joint, or a dislocation occurs at this spot. In some rare cases such a form of violence may displace the whole sternum inwards, this bone being either separated from the costal cartilages, or these latter structures being fractured across, in which case the thoracic viscera may be severely or fatally injured. Fractures here may also occur in association with other factures in severe smashes; thus, if a patient fall from a height on to his head, the body may be forcibly doubled up, the spine and sternum both being broken across.

The sternum alone may be fractured when the body is forcibly bent or extended, the former being probably due, as was first shown by Rivington,[1] to the forcible contact of the chin with the sternum, as may occur from blows on the head, or rarely during wrestling. The latter may be due to overarching of the sternum, and generally arises from sudden and severe force, the body being bent backwards by falling across some projecting object. Poland and Lyell[2] record several cases of fracture of the sternum due to excessive muscular contraction, but this cause is rare.

In the severe cases with many other fractures the deformity may be very great, and the condition of the patient, owing to the injury to the thoracic viscera, such as precludes any hope of successful treatment.

If the condition be one of fracture of the sternum alone, unassociated with any injury to the thoracic viscera, there will be localized pain, increased by coughing, pressure, or attempts to flex or extend the body. In the majority of cases the fracture is a simple transverse one, occurring close to the manubrio-sternal joint, although any portion of the body may be broken across. In such cases the upper portion is usually displaced backwards behind the lower, when it becomes locked. The patient then stands in a position of flexion, the head and shoulders being markedly bent forward. Cyanosis and dyspnœa may be present. Examination of the sternum will show a well-defined prominence corresponding to the upper end of the lower fragment, above which is a deep depression. In other cases there will be no overlapping of the fragments, crepitus and abnormal mobility being alone obtained, and these only with difficulty, steady and forcible pressure suddenly relaxed being the most certain means of eliciting them.

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[1] *Med. Chir. Trans.*, vol. lvii., 1874.

[2] *A System of Surgery*, Holmes and Hulke, 1883, vol. i., p. 812.

If the sternum with or without the costal cartilages be driven in as a whole, there is a well-marked and characteristic depression of the whole front of the chest. Such a condition is more prone to occur in younger patients, and is generally coupled with injury to the thoracic vessels, the heart, or the lungs, although cases may occur without these complications, the patient then often being remarkably free from symptoms.

Longitudinal fractures of the sternum are extremely rare, and congenital clefts in the bone must not be mistaken for this condition.

Treatment.—In those cases where the fracture of the sternum is only one of more severe injuries, no treatment will be undertaken to relieve the deformity. With a simple fracture of the sternum with overlapping of the two ends, the condition is, however, much more hopeful. Several cases have now been recorded where spontaneous rectification of the deformity has occurred during sudden acts of sneezing, coughing, bending, or even turning over in bed. If this does not occur, attempts should be made to overcome it. The patient, being placed on his back on a hard table, with a pillow beneath his shoulders, is so arranged that the head hangs freely beyond the edge of the table. An assistant now compresses the lower ribs so as to increase the arch and elevate the lower fragment, at the same time fixing the lower part of the trunk. The head and shoulders are then gradually extended by bending them backwards over the pillow and the edge of the table. Scudder[1] advises that this may best be done by raising the arms above the head and rotating them outwards slowly and forcibly. If this succeed, the replacement occurs with a snap. The patient should then be returned to bed, the chest being fixed with bands of adhesive strapping passing round as high up as possible, abdominal respiration being alone allowed. The patient is, if possible, kept on his back for three to four weeks, but if lung complications occur it may be necessary to support him in an inclined position.

If reposition by this means fail, recourse to operation may be necessary. This is only advocated if there be dyspnœa and cyanosis. Some cases have recovered completely with the deformity still persistent.

If operation be decided upon, a vertical incision should be made at the site of the fracture, the edges of the wound widely retracted, and the fragments, if possible, levered into position with a raspatory. If this be impossible, a small portion of the projecting lower fragment may be removed with a chisel, until the raspatory can be introduced. When reposition has been brought about, the ends may be fixed with a wire or plate with small screws if there be any tendency to recurrence.

Cases have been recorded where suppuration has taken place at the point of fracture, with necrosis of the surrounding bone. Here a free incision, with evacuation of the pus and removal of the fragments, should be made at an early date, otherwise infection may rapidly spread through the mediastinal tissues. This may even necessitate trephining a portion of the sternum.

Ribs.—The ribs are one of the commonest seats of fracture. The statistics of Guilt,[2] quoted by Poland and Lyell,[3] based on 51,938 fractures, show that they form 15·9 per cent. of all fractures. They are much more common in elderly men.

Certain ribs are much more prone to fracture than others

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[1] *The Treatment of Fractures*, 1907.
[2] *Archiv Klin. Chir.*, Bd. xxv., 1850.
[3] *A System of Surgery*, Holmes and Hulke, 1883, vol. i., p. 806.

—thus, the eleventh and twelfth, being short, buried in muscles, and unattached at their anterior extremities, are very rarely fractured; the eighth, ninth, and tenth, being only attached to the costal cartilages by their anterior extremities, will be more elastic than those above, and thus less frequently affected; while of the ribs above these, the fourth, fifth, sixth, and seventh, being the more prominent and the most exposed to violence, are the most commonly broken. Fractures of the upper three ribs are rare. Forcible depression of the clavicle may at times fracture the first rib. Fractures of the second rib alone are very rare.

There are two main varieties of fracture:

1. *Due to Direct Violence.*—If the violence be localized to a relatively small area, as may occur from a kick by a horse or a blow from a waggon-pole, two or three ribs will be fractured. In these cases the damage occurs at the site of the injury, and the ends of the bone are driven directly inwards, and may be comminuted, the loose portions being then often driven through the pleura (Fig. 21, B). This variety is very prone to be associated with injury to the underlying viscera, especially the lungs.

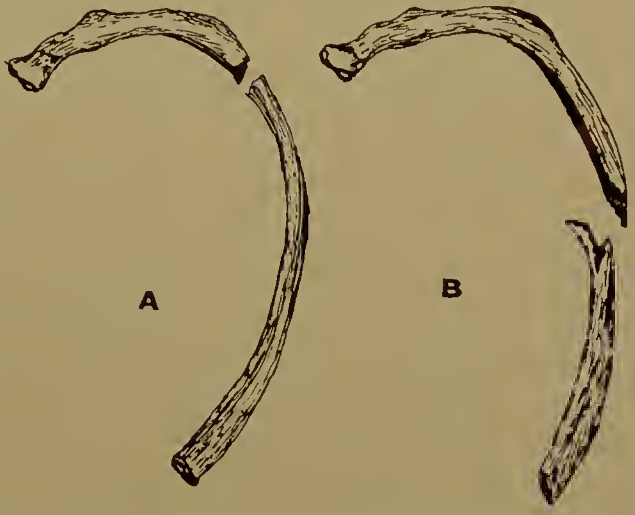

FIG. 21.—DIAGRAMMATIC REPRESENTATION OF A FRACTURE OF A RIB.

A, From indirect violence; B, from direct violence.

There may be signs of local trauma, bruising, and perhaps laceration, of the skin, and the patient will complain of very severe pain at the site of injury, increased by movements of the body and by deep respirations, such as are produced by coughing or sneezing. At these times crepitus may be present, and may be felt by the surgeon or by the patient himself. If the pain be severe, the patient may walk with his body doubled over towards the affected side, as he finds that this position, by diminishing the movements of this side of the thorax, limits the pain. Thoracic complications must always be looked for. In most cases these take the form of slight hæmoptysis, often not amounting to more than a rusty sputum. The escape of blood is sometimes more profuse, and takes place either into the bronchi, when it is expectorated, or into the pleural cavity, to form a hæmothorax. Rarely the rent in the lung may be so severe that the pleural cavity rapidly fills with blood, and if the hæmorrhage does not cease death soon ensues. Similar hæmorrhage may occur from rupture of an intercostal artery. In other instances air may escape from the lung, and this may pass into the subcutaneous tissues, giving rise to a surgical emphysema, which may be small and localized, or very extensive, passing even to the face and limbs; or it may make its way into the pleural cavity, giving rise to a pneumothorax. It is remarkable, however, how often an area of localized emphysema of the subcutaneous tissues is seen without any evidence of pneumothorax, the explanation possibly being that collapse of the lung is prevented by the presence of old pleural adhesions.

Occasionally the corresponding ends of several ribs may be driven inwards, so that the other extremities overlap them, a marked depression and succeeding elevation thereby being formed. In such cases fibrous union alone, with repeated attacks of slight hæmoptysis, spread over months or years, may take place.

2. *Due to Indirect Violence.*—This is the more common of the two causes. The thorax as a whole is compressed, and generally in an antero-posterior direction. The compression may be gradual, as when a patient is squeezed in a crowd, or more sudden, as from a severe blow on the sternum. The fractures may be single or multiple; usually three or four ribs are broken. Most commonly the site of the lesion will be close to the angle of the rib. The chest, being compressed antero-posteriorly, tends to be flattened out in this plane, the ribs giving at the point at which they naturally are most bent—that is, close to the angle (Fig. 21, A). In some cases, however, the lesion occurs midway between the points of pressure—that is, about the mid-axillary line.

In all such cases there will be a tendency for the ends to be driven outwards, a condition, however, which is rarely found post mortem, owing to the ribs passing back into their normal position. This tendency is sufficient to make thoracic complications much rarer than in the previous variety. The line of fracture, also, is much more likely to be transverse and single, so that no loose fragments occur, and less displacement takes place.

The symptoms here will be much less marked, and if only one rib be fractured there may be considerable difficulty in arriving at a correct diagnosis. The patient will complain of localized pain, limited to one area, and greatly increased on deep breathing, coughing, or sneezing ; and he may here, also, walk with the body flexed towards the affected side. There will generally be no deformity of the ribs and no evidence of local trauma. Crepitus is difficult to obtain, but is best elicited by pressure upon the spine and sternum, when the two ends are projected outwards and made to rub one against the other. If slight, it may only be heard with the stethoscope. This action will also be accompanied by pain, always localized to the site of the injury, which fact is perhaps one of the most valuable signs in forming a correct diagnosis.

Emphysema and thoracic complications are rare. Sometimes a single fracture may be greenstick in nature.

In many cases of severe trauma a large number of ribs are fractured, and it is then difficult or impossible to say into which category the injury falls, as the bones may be broken both at the seat of the injury and at the angle. Such cases are often accompanied by other severe injuries, such as fracture of the sternum and spine, severe laceration of the lungs, or even the heart, and rupture of some of the abdominal viscera, and are thus often fatal.

Very rarely the ribs may be fractured from muscular violence. Poland and Lyell[1] mention ten cases where this had taken place. It is more common in the lower or floating ribs, and in bones that are the seat of some previous pathological change.

Prognosis.—Fractures of single ribs, if due to direct violence, usually unite rapidly, the patient being free from all symptoms by about the end of three weeks, and no complications generally result. Occasionally the amount of callus is excessive, and involvement of the corresponding intercostal nerve takes place, in which case the patient will complain of severe pain referred along the course of the nerve. This pain may cease as the nerve becomes sufficiently compressed to lose its function, and if only one nerve be so involved no anæsthesia will result. In elderly patients suffering from bronchitis and emphysema, a claim for compensation is often made on the ground that an old fracture has led to a chronic pleurisy which is the cause of the symptoms; but if there has been no depression of the fragments and no lung symptoms at the time of the accident, such a supposition can be dismissed, as there is no evidence in favour of this course of events. The physical signs will also show the nature of the lung disease.

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[1] *A System of Surgery*, Holmes and Hulke, 1883, vol. i., p. 807.

In cases where a portion of the bone is depressed, lung symptoms may persist for a long time. The hæmoptysis which will be present at the time of the accident will continue, perhaps, in slight amounts more or less continuously, or in larger quantities at longer intervals, and especially in those rarer cases of overlapping of several of the ribs. An operation may be required to remove the fragments which are projecting into the lung.

If the fracture be compound, sepsis with necrosis of portions of bone may occur, and continue, perhaps, for months.

Injuries of the viscera associated with pleural hæmorrhage are often fatal unless some open operation be undertaken. Thus, rupture of an intercostal artery or severe lacerations of the lung may lead to fatal hæmorrhage. Smaller lacerations of the lung with slight hæmoptysis, or even a well-defined hæmothorax, may clear up entirely. Pneumothorax and surgical emphysema, although causing considerable discomfort to the patient, usually undergo spontaneous cure.

Treatment.—In the slighter cases with no displacement, the ribs of the affected side should be fixed as far as possible, so that, all movements being prevented, the pain is relieved until union has occurred. It is only possible to fix the ribs in a position of complete expiration. This may be done as follows:

A strip of adhesive strapping 2 inches wide is taken; one end is fixed on to the patient's chest at the level of the top

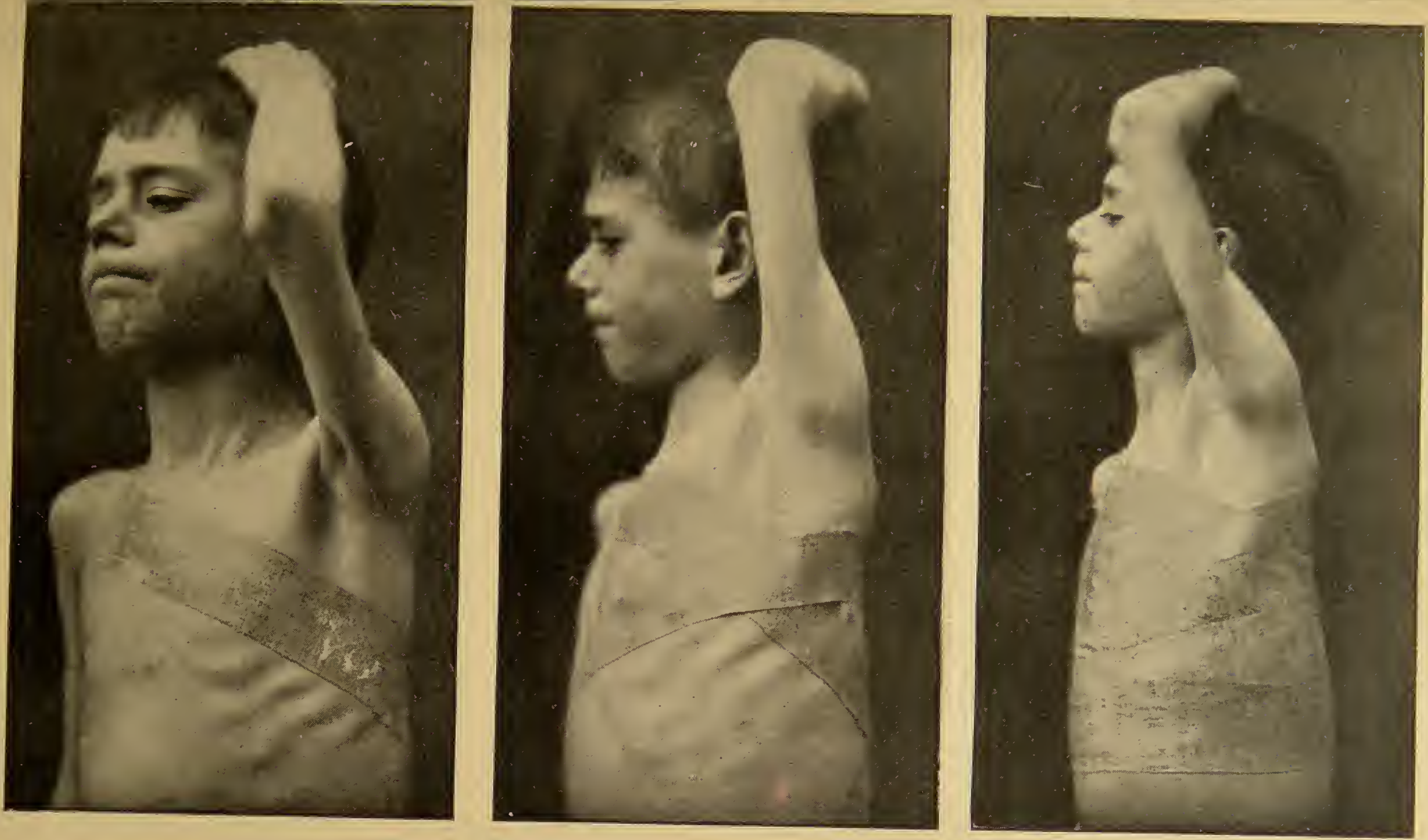

FIG. 22.—METHOD OF STRAPPING ONE SIDE OF THE CHEST FOR FRACTURED RIBS.

of the sternum, and 3 inches beyond it—*i.e.*, on the sound side. The patient is now directed to expel all air from his lungs, and when the chest is completely collapsed the strip is wound round the affected side so as to meet the ribs in the mid-axillary line at a right angle. It should be long enough to pass 3 inches beyond the spine behind. A second strip is applied in a similar manner. This commences behind at the level of the second dorsal spine and 3 inches beyond it, passing downwards and forwards to cross the first piece at an angle of 135°. A third strip is applied parallel to the first and overlapping it for about one-third of its width, a fourth parallel with the second, and so on until the width of strapping at the point of crossing is about 6 inches. Each piece must be applied with the chest completely collapsed, as by this means the ribs are firmly fixed in a position of full expiration.

The strapping is bandaged over to prevent the clothes sticking to its surface, and the patient is allowed to walk about. The relief obtained by such a method of treatment is remarkable, all pain usually ceasing from the time of its application. The strapping should be kept on for three weeks, being changed if necessary. A bandage may be applied for a further week if required.

If there be any complication, such as hæmoptysis, the patient should be kept in bed. It is often advised that in such cases the ribs should not be strapped, as by this means the fragments may be driven still farther into the lung. For this reason it may be best to keep the patient still in bed, with a bandage round the chest, all cough being prevented by the administration of sedative mixtures. If this fail it will usually be found, however, that complete relief of symptoms follows if the ribs be strapped in the manner advised above, while hæmoptysis soon ceases, the danger of this method probably being exaggerated.

If there be marked overlapping of several ribs, with severe deformity which cannot be reduced, it is advisable to cut down upon the ribs, as otherwise there will be constant irritation of the underlying lung. An incision should be made directly over and parallel with one of the ribs, the ends of which are bared and, if possible, levered into position. If this be not possible, a portion of the overlapping bone is best excised, when the two ends will readily come into line, fixation not generally being required. If there be four or five ribs so fractured, an incision parallel with the line of the fractures will be found more convenient than one parallel with the ribs. The operation is best performed as soon as the patient has recovered from the shock of the accident, and before any fibrous or bony union has had time to take place.

Emphysema and pneumothorax as a rule require no treatment, but either may be so extensive and cause so much discomfort to the patient that removal of the air by aspiration from the thorax, or by aseptic puncture from the skin, may be called for.

If there be evidence of extensive hæmorrhage within the thoracic cavity, which shows no sign of abatement, an operation may be undertaken for its relief. Schütte[1] strongly advocates this method of treatment. He finds from recorded statistics that the mortality in untreated cases varied from 40 to 60 per cent., whilst in twelve recorded cases where operative treatment was carried out nine recovered.

He advises that a horseshoe-shaped incision be made. In cases of fracture this should be so fashioned that the site of fracture corresponds with the middle of the flap, and the base with the sternum. The bones and parietal pleura are divided and turned backed.

The lung may then be drawn out of the wound; any laceration of this viscus may be closed with catgut sutures, and the hæmorrhage thus controlled. The pleura is cleared of blood-clot, the flap replaced and sutured in position. No tube is required.

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[1] *Münch. Med. Woch.*, June 30, 1908, p. 1386.

CHAPTER VII

FRACTURES OF THE CLAVICLE

THE clavicle is more commonly fractured than any other bone in the body. Flower, Morris, and Hulke,[1] give 165 cases of fracture of the clavicle out of a total of 1,858 fractures of all varieties.

This frequency is due to the fact that with the arm abducted blows are transmitted from the hand or elbow to the trunk through the clavicle, which forms the weakest spot in the line of bone extending from the wrist to the sternum.

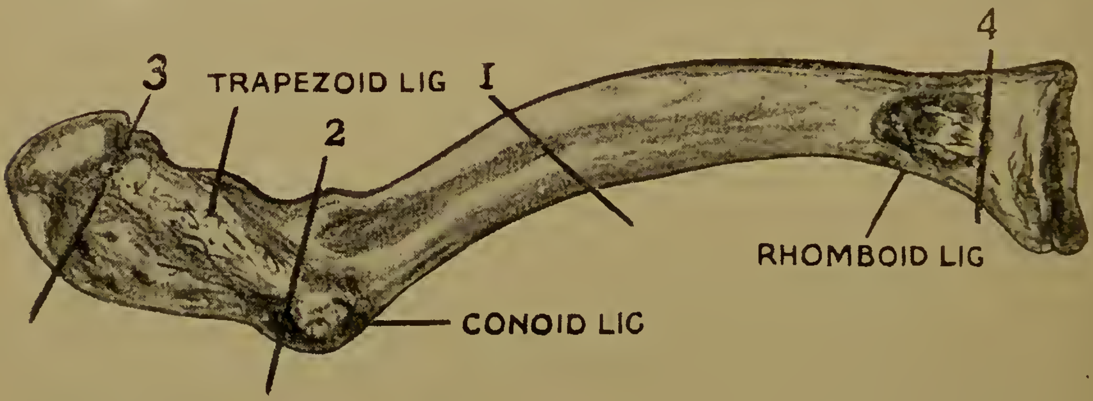

FIG. 23.—UNDER-SURFACE OF RIGHT CLAVICLE, SHOWING SITES OF FRACTURE.

In such cases the tendency to fracture is increased by the curves of the bone, although the elasticity is also increased thereby.

The clavicle may be fractured at either extremity or in the shaft (Fig. 23).

Fracture of the Shaft [1].—This is much the most common site of fracture. It occurs in the middle third at the point of junction of the two curves of the bone. It is nearly always due to indirect violence. The patient falls either forwards or sideways, and strikes the ground with his arm outstretched and abducted. A common example of such an accident is that where a football player is thrown forward when gripped by the legs. In may occur in the same way when the elbow strikes the ground. In both these cases the arm is in one straight line with the clavicle, this bone being the only structure which keeps the arm from the trunk. The fracture will naturally be more prone to take place, under these circumstances, at that point at which there is an alteration in this line of bone. This is seen to be the case, the clavicle being nearly always fractured obliquely from behind, either forwards and inwards or forwards and outwards, at about the middle of the bone—*i.e.*, at the junction of the two curves. These fractures very commonly occur in young children, and may then be due to relatively slight trauma, when they are often greenstick in nature.

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[1] *A System of Surgery*, Holmes and Hulke, 1883, pp. 946 and 995.

More rarely fractures in this position may be due to direct violence. The most prominent point of the forward convexity is then the seat of the trauma. Such a condition may arise from weights falling upon the patient, in some cases of "run-over" accidents, and more rarely from blows with the fist at this spot.

The deformity at the site of the fracture is very characteristic. The inner fragment is said to be tilted upwards by contraction of the sterno-mastoid muscle, but in reality the displacement of this portion is very slight, as it is firmly bound down to the first rib by the rhomboid ligament. The displacement of the outer fragment is marked, and is threefold in nature. It is tilted in such a way that its inner end is slightly raised, and its outer end markedly depressed. This is caused by the weight of the arm acting in a downward direction on its outer extremity. It is drawn inwards so as to overlap the inner fragment, crossing it either in front or behind, according to the direction of the obliquity of the fracture (Fig. 24). This is brought about by contraction of the pectoral muscles in front and the rhomboids behind.

The third factor in the displacement is that the outer fragment is tilted forwards. This is due to the fact that, when once the resistance of the clavicle is removed, the scapula tends to embrace the side of the thorax, the point of the shoulder thus moving forwards and inwards.

The degree of predominance of either of these factors varies in the individual case, and the treatment must differ according to which is the most marked.

Symptoms.—There will be considerable pain at the site of the fracture; all movements of the shoulder will be difficult, and cause a great increase of the pain, which will be of a grating, grinding character, the patient often describing it as a feeling as though the shoulder were falling off. The attitude is characteristic: the patient walks supporting the affected arm in the opposite hand. The head is held over towards the side of the lesion, and the shoulder is dropped visibly downwards and forwards. Narrowing of the shoulder may also be distinct.

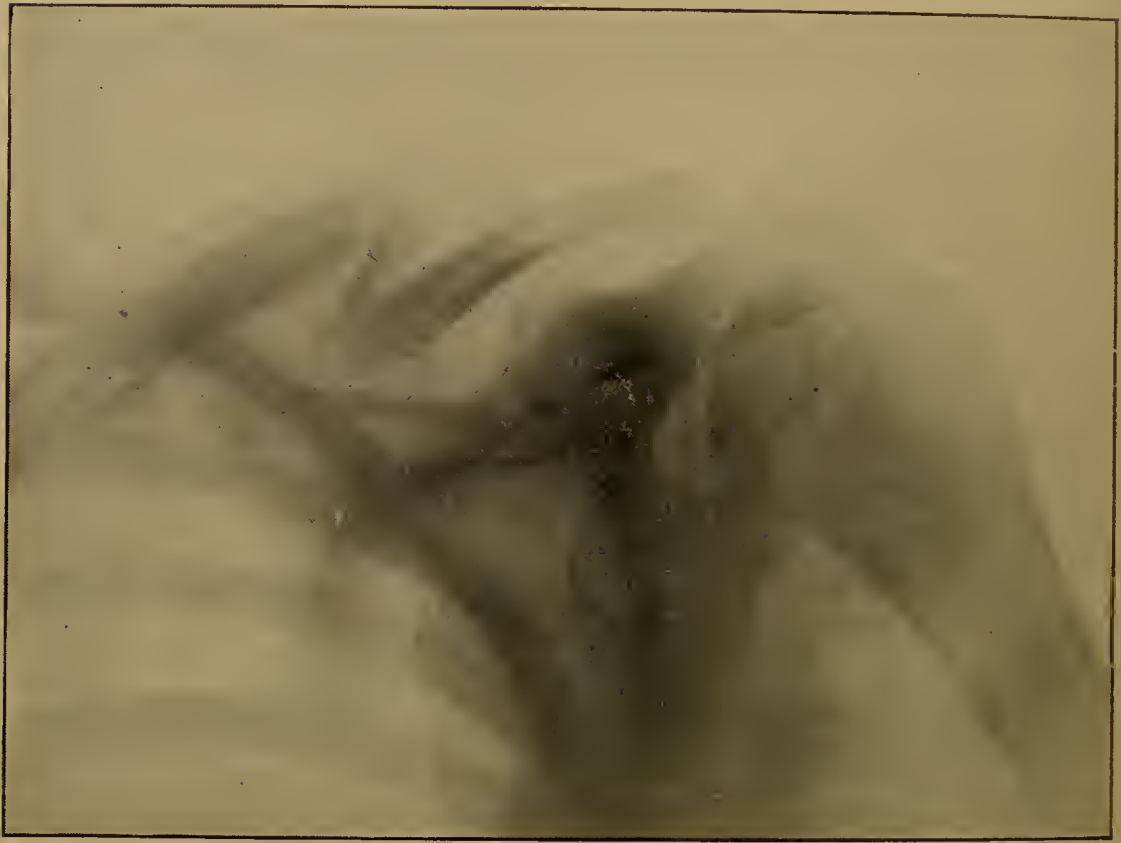

FIG. 24.—FRACTURE OF SHAFT OF THE CLAVICLE.
(Mr. Furnivall's Case.)

On examination, some irregularity in the line of the bone can nearly always be felt, and may, indeed, be visible. If the fingers of one hand be held over the bone at this spot, and the shoulder or arm be moved with the other hand, especially in the upward direction, crepitus may easily be obtained and abnormal mobility becomes manifest.

In some cases the fracture may be comminuted, and loose portions of bone may be felt beneath the skin. Very rarely the subclavian vessels or the cords of the brachial plexus may be injured, either at the time of the accident or at a later date from involvement in callus. Pressure upon the vessels may lead to gangrene of the arm. Fractures of the first rib are usually accompanied by a fracture of the clavicle.

In young children with a greenstick fracture the symptoms will be much less marked. The pain may be so slight that no attention is directed to it. Likewise deformity will be smaller in amount, and, unless there be sufficient displacement to cause local swelling and tenderness, it may pass entirely unnoticed. In several such cases the presence of a large mass of callus is the first symptom which excites suspicion. Excess of callus of this nature is common in young children, but it rapidly decreases after a few weeks.

Treatment.—Very many different methods have at times been advocated for the treatment of these fractures, only to fall into disuse. The reason of this is that no one method should be used in all cases, but the individual deformity should be carefully studied and means taken to rectify it.

The most common deformity is that in which the point of the shoulder has dropped downwards and forwards. This may be readily overcome by Sayre's method of treatment. The axilla, hand, and fingers, are thoroughly dusted with boric acid powder. A strip of Gamgee tissue, 3½ inches wide, is now wound round the arm as high up as possible. A long strip of adhesive strapping, 3 inches wide, is then taken. One end of this is made into a loop which loosely encircles the Gamgee tissue, the ends of the loop being fixed with a safety-pin, and the adhesive surface of the strapping being on the outer side of the loop. By pulling firmly upon the long end of the loop the shoulder is drawn backwards, and may be fixed in this position by winding the strapping, the adhesive surface of which is next to the skin, around the chest. It should be long enough to completely encircle the chest (Fig. 25, A). A piece of cotton-wool dusted with boric acid is now placed in the axilla to keep the skin of the arm away from that of the chest. The hand of the affected side is brought up to, and placed upon, the opposite side of the chest, just below the clavicle, the skin surfaces being separated by a layer of cotton-wool dusted with boric acid. A second strip of strapping is taken, and a hole cut in it to receive the point of the elbow, which is drawn forward as far as possible, and fixed in this position by winding this strip obliquely over the sound shoulder (Fig 25, B). By this means the upper part of the arm is fixed by the first band, which forms a fulcrum, so that when the elbow is pulled forward the shoulder is drawn back. This may be aided by direct pressure upon the shoulder. The loop passing round the elbow at the same time elevates the arm and shoulder.

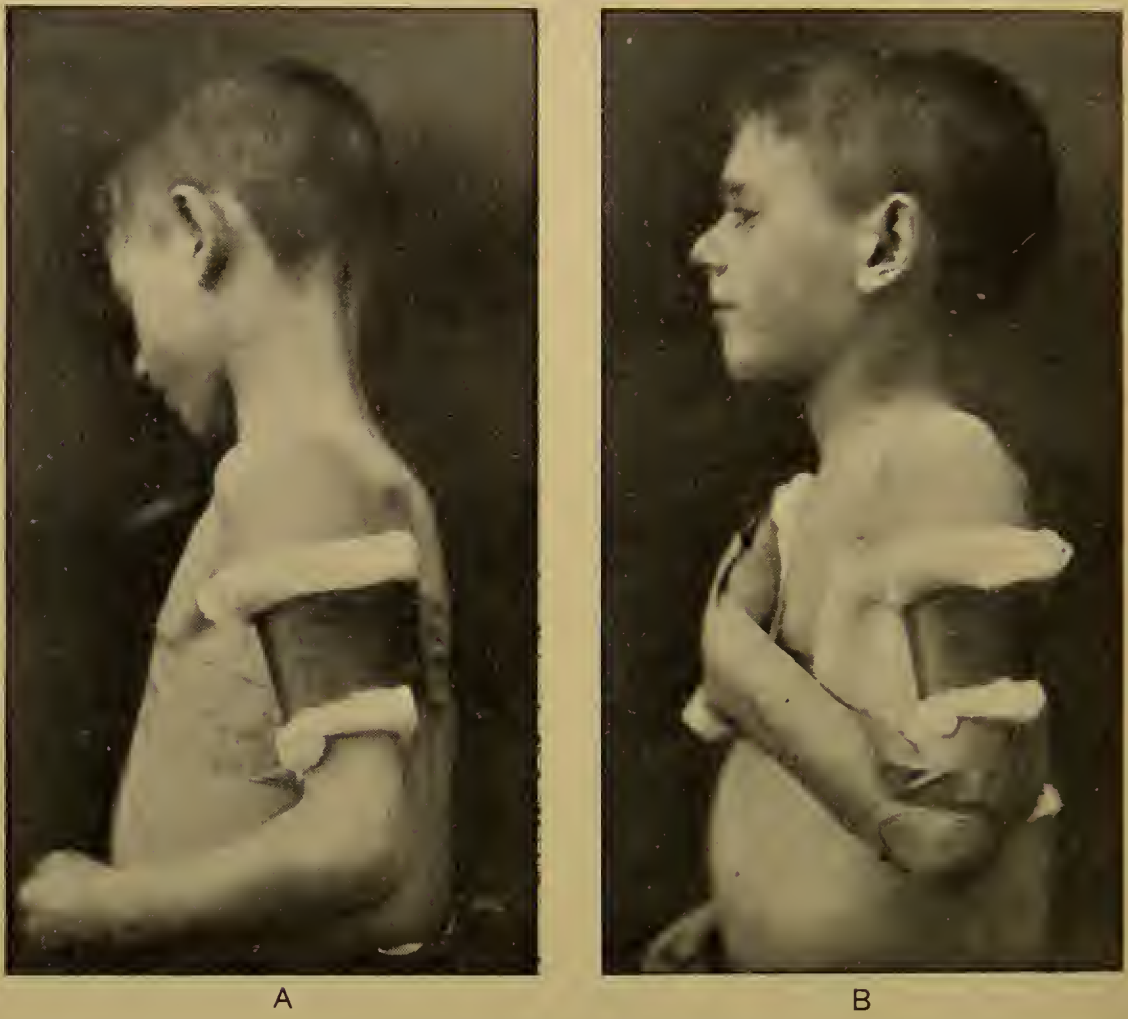

FIG. 25.—SAYRE'S METHOD OF TREATING A FRACTURE OF THE CLAVICLE.

The opening to receive the tip of the elbow has been made rather too large.

A bandage may be applied over the strapping to more securely fix the arm to the side.

If the chief deformity be one of shortening of the shoulder from overlapping of the two fragments, a large but soft pad should be placed in the axilla, and the shoulder then levered out by pressing the elbow to the side, in which position it is fixed by a bandage encircling both arm and trunk.

If necessary, this pad may be used in combination with Sayre's method.

In either case the retentive apparatus should be maintained in position for three weeks, the strapping being changed every week. Frequently the patients after a short interval complain of severe pain in the fingers, of a cramplike nature. This may be remedied by allowing them to be moved at an early date—*i.e.*, in about ten days after the injury.

After removal of the retentive apparatus a sling should be worn for another week. If there be difficulty at first in overcoming the deformity, the patient should be placed on his back on a firm table or mattress. In this position the deformity tends to reduce itself, and the retentive apparatus may then be applied. In severe cases it is best to place the strapping on in this position, and to keep the patient flat on his back until union has taken place, but a warning must be given here against the treatment often advised of simply keeping the patient flat on his back with no retentive apparatus. Such a position is almost impossible to retain, and the results of such treatment are generally very poor.

If there be only a greenstick fracture, attempts should be made to overcome any deformity by steady pressure, an anæsthetic being administered if necessary. The arm is then simply bandaged to the side for a period of two weeks, a sling being worn for a further week. In these patients, generally young children, care must be taken to prevent chafing of the skin. All points of pressure must be protected by careful padding and a liberal use of boric acid powder; skin surfaces must be kept from apposition, and all naturally moist areas, such as the axilla and palm of the hand, frequently examined, carefully cleansed, and the dressings reapplied.

In some cases both clavicles may be fractured. Such patients should always be confined to bed, deformity overcome when the patient is in the prone position, and the limbs carefully fixed. A well-powdered pad should be placed in either axilla, and the arms bandaged over them to the trunk. It will be found impossible to use Sayre's method, as the elbow loop of one side will press upon the fracture of the other side.

In some rare cases it may be necessary to resort to open operation. Thus, if it be found impossible to overcome the deformity, and this is very severe, it is better to cut down and wire the ends. Any injury to the vessels or nerves either at an early or a later date may necessitate operative measures. In a very few cases, also, no union may take place, probably from the interposition of some adventitious structure, especially a portion of the subclavius muscle. This can, of course, only be removed by open operation. These complications are, however, all very unusual.

Fracture of the Acromial End.—Fractures here may be due to direct violence from blows upon the shoulder from above, or from indirect violence, the patient falling upon the outstretched hand with the arm less abducted than in the case of the common variety. The head of the humerus is then driven directly upwards, and may thus fracture this end of the clavicle, with or without injury to the acromial process. They are much less common than the first-described variety.

Two types may be recognized :

(*a*) *Between the Conoid and Trapezoid Ligaments* [2].—In this case there is a more or less transverse fracture, but, since both fragments are firmly fixed to the coracoid process—the inner by the conoid, and the outer by the trapezoid ligament—no deformity will result. This type is more commonly due to direct violence. There will be local bruising and swelling, and on movements of the shoulder crepitus may with difficulty be obtained. The arm should be kept in a sling for two to three weeks, passive movements of the shoulder, elbow, and wrist, being given at the same time.

(*b*) *Outside the Trapezoid Ligament* [3].—This variety is also most commonly due to direct violence. Often there is no deformity, the inner fragment being firmly fixed to the coracoid process by the conoid and trapezoid ligaments, whilst the outer is attached to the acromion process. In some cases, however, the outer fragment is tilted downwards so as to lie nearly at right angles to the rest of the bone. This is due to the extent of the violence which drives the arm downwards, and is probably associated with partial or complete rupture of the coraco-clavicular ligaments. If there be no displacement, the symptoms will consist of pain, swelling, and perhaps crepitus. Good results will follow if the arm be bandaged to the side. If, however, the outer fragment be tilted, there will be very definite deformity, the condition resembling a dislocation at the acromio-clavicular joint. There will be a marked prominence corresponding to the outer end of the inner fragment, this prominence largely disappearing when the shoulder is raised. Attempts to overcome the deformity are not as a rule very successful. The arm may be supported by the application of Sayre's apparatus. If this fails, and the deformity be sufficiently great to demand it, the fragments may be cut down upon and wired.

Fracture of the Sternal End [4].—Fractures here are unusual. They may be due to direct violence, or to blows upon the tip of the shoulder, the mechanism being identical with that producing a dislocation of the sternal end. Usually there is no displacement, the outer fragment being firmly fixed to the first rib by the rhomboid ligament. In some rare cases, however, this ligament may be ruptured, when much displacement of the outer fragment takes place, it passing either forwards, backwards, or upwards, and overriding the inner fragment. Reposition can usually be brought about by backward extension of the shoulder. If this fail, a large pad should be placed in the axilla, and the arm levered to the side, when the outer fragment will be drawn into position. The arm is then bandaged to the side, and fixed in this position for three to four weeks.

Separation of the Epiphysis.—The clavicle is developed in membrane, a centre appearing for the shaft at the sixth week of fœtal life. A separate centre for the sternal end appears at about the twentieth year, and joins with the shaft at the twenty-fifth year. Owing to the short time during which an epiphysis is present, its separation will be a very rare accident. J. Hutchinson junior[1] records three cases. Separation will be produced by the same injuries that may lead to fracture of the sternal end or dislocation of the sterno-clavicular joint. The symptoms and treatment will be similar to that of a fracture of the sternal end.

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[1] *Brit. Med. Journ.*, July 16, 1887.

Prognosis of Fractures of the Clavicle.—Fractures of the shaft, if treated in such a way that deformity is overcome, are usually followed by very good results, the patient being able to return to his work at the end of six to eight weeks. At the sternal end good results also follow, unless the rhomboid ligament be ruptured, in which case a certain amount of permanent weakness may result. At the acromial end, the only variety followed by disability after about six to eight weeks, is that of the outer end, and this may necessitate operation, but some weakness of the shoulder may even then persist.

CHAPTER VIII

FRACTURES OF THE SCAPULA

Fractures of this bone are rare, but may be of many different types (Fig. 26). They are mostly due to direct violence. They may be considered as follows:

Of the Body [1].—Although the body forms a thin and somewhat delicate plate of bone, fractures here are rare, owing to the extensive covering of muscle on both the dorsal and ventral surfaces. Should a fracture occur, it is always the result of direct violence, and is thus often accompanied by injury to the underlying ribs. It may be due to forcible blows on the back, such as occur when a man is caught between the buffers of a train, or to crushes and "run-over" accidents. Most commonly the fracture is comminuted, a radiating fissure around the neck, extending across the body below the spine (Fig. 27), being the usual variety. In other cases the fracture is irregularly transverse, the lower part of the body and the inferior angle being separated. In both of these varieties but little displacement takes place, owing to the firm and extensive attach-

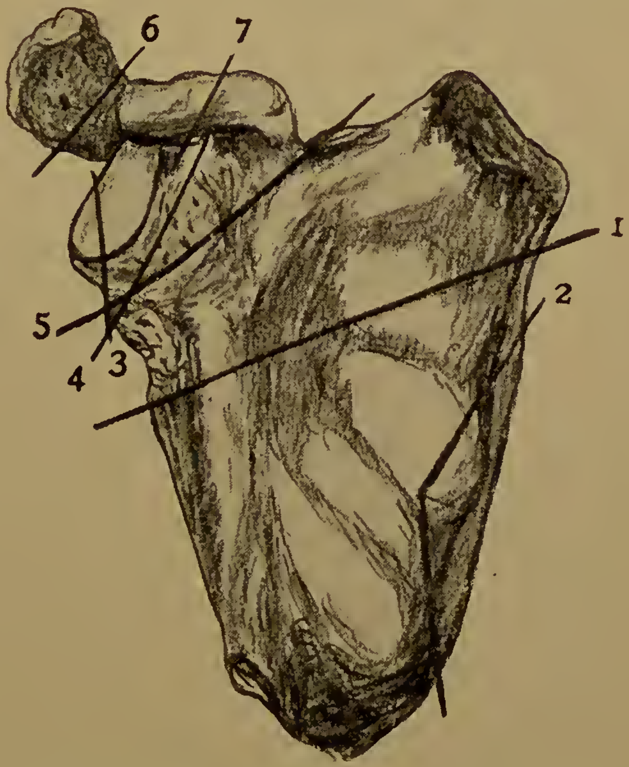

Fig. 26.—Scapula, showing Sites of Fracture.

ment of the muscles. More rarely a long flake of bone may be torn off one of the borders, most commonly the vertebral, in which case the separated portion may be displaced, the vertebral border being drawn forwards and outwards by the serratus magnus, so as to lie in front of, or deep to, the rest of the bone.

Symptoms.—The patient will complain of severe pain in the region of the scapula, which will be greatly increased on all attempts at movement of the arm and shoulder. Locally much bruising and swelling may be present, the part will be tender on pressure, and different portions of the scapula may be grasped and found to be freely movable, a small portion of the whole bone alone moving. By such means crepitus is as a rule easily obtained. If the underlying ribs be also fractured, the symptoms peculiar to that condition will be present. In severe cases the spine and thoracic viscera may be injured.

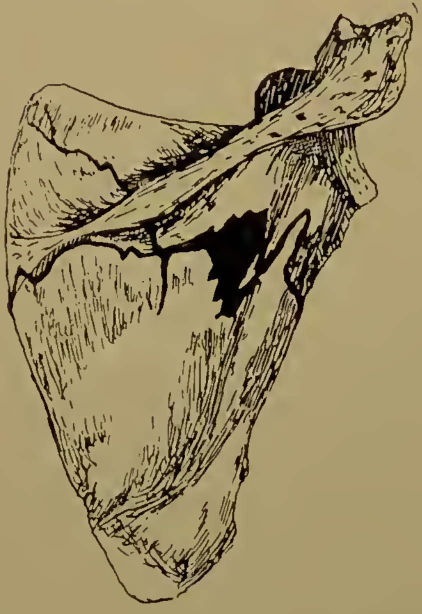

FIG. 27.—STELLATE FRACTURE OF BODY OF SCAPULA. (London Hospital Museum, No. 355.)

Radiography will not generally be of much value in arriving at a diagnosis, as the shadow is blurred by the position of the ribs. The axillary border is, however, free from them, so that the presence of any abnormality in this position may be determined, and this means of investigation should therefore be used wherever possible.

Treatment.—If uncomplicated and but little displacement be present, the scapula should be bound to the thorax with cotton-wool and a bandage. The arm is at the same time fixed so as to prevent all movements of the fragments, the most comfortable position being that with the arm in front of the chest. Here, as with fractures of the clavicle, the axilla and hand should be lightly padded with powdered cotton-wool.

If the underlying ribs be fractured, the chest should be first strapped, as advised on p. 99. If the vertebral border be separated [2] and displaced outwards, it will generally be found possible, by drawing the shoulder forwards, to bring the parts sufficiently into apposition. Should this fail and disability result, it may be necessary to fix the part by open operation.

At the end of three weeks union is usually firm, and the bandages may then be left off. Gentle passive movements should be ordered, and the arm carried in a sling for another two weeks. Powerful efforts involving the use of the arm should not be allowed for another three to four weeks.

Of the Neck.—The neck of the scapula may be regarded as that portion external to the origin of the spine. It includes the glenoid cavity. Three varieties of fracture may be recognized here, but all are rare :

(*a*) *Through the Glenoid Cavity* [3].—This results from severe violence applied to the head of the humerus, and thus may be associated with a fracture of the neck of that bone. The lower portion of the glenoid cavity is separated by an oblique fracture.

The patient will complain of severe pain in the shoulder, which is swollen and tender. Movements, especially abduction of the arm, are decreased and painful, and crepitus may at these times be obtained.

The diagnosis can only be made with certainty by the aid of a radiograph. The displacement of the fragment will be but slight.

For the first few days the arm should be bandaged to the side, to prevent all movement and tendency of the shoulder to drop. As soon as the effusion is absorbed—*i.e.*, after four to five days—passive movements and massage should be commenced, so as to limit subsequent adhesions. Meanwhile the arm should be carried in a sling. A certain amount of traumatic osteo-arthritis of the joint is almost certain to follow, but is limited by early passive movements.

(*b*) *Through the Anatomical Neck* [4].—This may be caused by a similar type of violence. The line of fracture lies entirely behind the glenoid cavity, which is separated. Injuries to the neck of the humerus may also be present. The shoulder is somewhat flattened and the arm lengthened, the separated portion of the scapula being displaced downwards and inwards.

There will be pain and swelling, with limitation of movement and crepitus. Owing to the flattening of the shoulder and undue prominence of the acromion process, the condition may be mistaken for a dislocation of the humerus downwards. From the axilla, however, it may be possible to distinguish not only the head of the humerus, but the separated portion of the scapula. The lengthening and flattening of the shoulder may be overcome with crepitus when the elbow is pushed upwards. A radiograph is generally required to confirm the diagnosis.

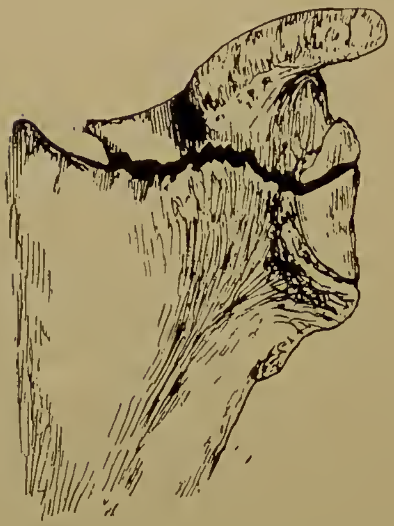

FIG. 28.—FRACTURE AT BASE OF CORACOID PROCESS. (London Hospital Museum, No. 356.)

The suprascapular notch is in this case a complete canal.

(*c*) *Through the Surgical Neck* [5].—In this case the line of fracture will be still farther inwards, the separated portion of the scapula including the coracoid process. The line of fracture may run obliquely through the glenoid cavity instead of below it (Fig. 28). It also may be caused by a blow upon the head of the humerus. Flattening of the shoulder and lengthening of the arm will be more marked than in the last variety, with a corresponding increase in the prominence of the acromion process. The arm will not be abducted from the side in the manner characteristic of a dislocation, and distinct crepitus with obliteration of the flattening and lengthening will generally be obtained on pushing the elbow upwards.

In both these varieties treatment must aim at keeping the outer fragment supported in line with the body of the scapula. This may be accomplished by inserting a large soft pad of Gamgee tissue or cotton-wool in the axilla and binding the arm to the side, turns of the bandage passing beneath the elbow and over the opposite shoulder, so as to keep the humerus well supported. If this fails, a ∩-shaped axillary splint, as described for fractures of the upper end of the humerus, should be moulded and applied. By its means the shoulder is kept up and flattening is overcome. This splint and bandage must be maintained in position for two weeks. At the end of that time passive movements may be commenced. At first these should be given with the axillary pad still in position, the elbow being carefully supported to prevent dropping, and only backward and forward movements allowed. After a few days rotatory movements to a slight degree may be added, but abduction should not be permitted until the end of three weeks, by which time the union will generally be firm. The elbow must, however, be supported in a sling for another two weeks, active movements being very gradual in onset.

Of the Acromial Process [6].—The acromial process is but rarely fractured, but such an accident may arise from direct violence applied to it. The separated portion may include only a small area outside the acromio-clavicular joint, or the line of fracture may be placed close to the spine, the greater part of the acromion, together with the acromio-clavicular joint, then being separated. In the first case, in addition to the signs of local trauma, a small portion of the tip of the acromion may be felt to be separated, and crepitus on movement obtained. The displacement is generally slight, owing to the wide attachment of the deltoid. Fixation of the arm and shoulder for two to three weeks is usually sufficient to allow good union to take place. In the latter variety the shoulder is depressed, but not as a rule to any marked extent, the fragment being supported by the clavicle. If, however, there be an accompanying fracture of that bone, the displacement will be much more marked, but the upper border of the head of the humerus will bear its normal relationship to the tip of the acromial process, and the position of the humeral head and the glenoid cavity within the axilla will be but slightly altered, thus distinguishing this rare fracture from a dislocation. The alteration in the line of the spine and acromial process, as felt subcutaneously, is generally distinct.

Treatment will be on the same lines as that for a fracture of the neck of the scapula, the shoulder being elevated by a pad in the axilla, and by bandaging the arm to the side, turns of the bandage passing beneath the elbow and over the opposite shoulder, so as to support the humerus. This position should be maintained for from three to four weeks, and the arm afterwards carried in a sling for two to three extra weeks. Passive movements may be commenced at the end of three weeks.

Of the Coracoid Process [7].—Fracture of this process is very rare. It is usually brought about by direct violence delivered on the projecting tip, but blows of this nature are more likely to strike the clavicle and to lead to a fracture of that bone. As a rule there is but little displacement, as the process is firmly attached by the conoid and trapezoid ligaments along nearly its whole length to the under-surface of the clavicle. In some cases, however, these ligaments may be ruptured, when the separated process is drawn downwards by the coraco-brachialis and short head of the biceps, and inwards by the pectoralis minor. It may be possible to arrive at a correct diagnosis from the presence of movement and crepitus of the bone, or a radiograph may be necessary.

If the displacement be slight, the arm should be bandaged to the chest, the elbow being drawn inwards across the chest and the forearm flexed, whereby the attached muscles are relaxed. The arm should be kept in this position for two to three weeks.

In the exceptional cases where much displacement is present, it may be necessary to fix the fragment into position. If so, an incision should be made, starting parallel with the middle of the clavicle, and passing outwards and downwards parallel with the inner border of the deltoid. The pectoralis major and deltoid are retracted, and the costo-coracoid ligament divided. By this means ready access is gained to the process. It may then be fixed either by a peg or a thin piece of silver wire.

Separation of Epiphyses.—The method of ossification of the scapula is shown in Fig. 29.

It is very rarely, however, that any of these epiphyses are separated. If so, the separation only in part follows the epiphyseal line, a portion of the diaphysis also being torn off. So very seldom does this occur, that no general lines of treatment can be laid down. If the displacement be great and not otherwise controllable, an open operation might be indicated.

Prognosis of Fractures of the Scapula.—Although firm union most commonly results, a long period often elapses before the patient can return to his work. In the case of fractures of the body this is largely due to the excessive violence by which they are generally produced. There may be underlying fractures of the ribs, and a certain amount of atrophy and stiffness of the muscles results. This is generally decreased by the use of massage and passive movements, so that simple cases may be enabled to return to their work at the end of about eight weeks. This class of case is, however, very prone to develop traumatic neurasthenia, and many complain of pain and weakness of the affected limb for months, or even years, after the accident; and it is very difficult, if, indeed, not impossible, to decide which of these patients are real sufferers, and which are carrying out a pure deception in order to gain compensation.

Fractures of the neck tend to be followed by some stiffness of the shoulder. This may largely be prevented by massage and passive movements, but even with these some six months will usually elapse before the patient is fit to return to his work; and even then some traumatic osteo-arthritis, with pain and limitation of movement, may persist for the rest of his life, a consequence which is much more prone to occur if the joint be encroached upon. Fractures of the acromion, if unassociated with other lesions, should show firm union in about five weeks. If passive movements be begun early, but slight disability should result; but here also some osteo-arthritis may follow. Fractures of the coracoid, if there be much displacement, are likely to be followed by a good deal of weakness of the arm.

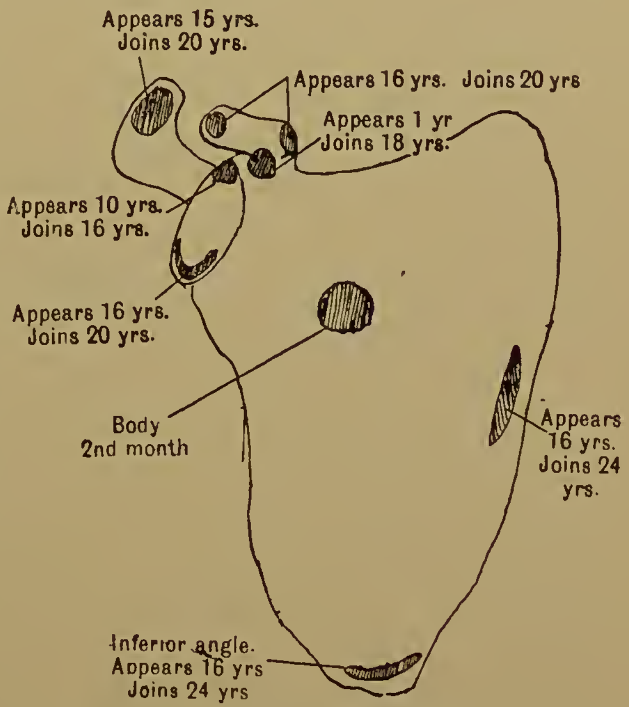

FIG. 29.—CENTRES OF OSSIFICATION OF THE SCAPULA.

CHAPTER IX

FRACTURES OF THE HUMERUS

The humerus, owing to the freedom of its movements, is a common seat of fracture, which may occur at almost any age. Owing to the fact that it is surrounded by muscles in practically the whole of its extent, accurate diagnosis, especially as regards the amount of displacement, may be accompanied with considerable difficulty. Immobilization is here more difficulty than with most of the other bones, so that non-union or malunion is not an uncommon event. Malunion even of a slight degree may cause quite an appreciable disability, so that, unless great care be taken in the treatment, the prognosis is likely to be unfavourable. As with the other long bones, fractures here may be divided into those of the upper extremity, those of the shaft, and those of the lower extremity (Fig. 30).

The Upper Extremity.

The Anatomical Neck [1].—A true fracture of the anatomical neck is more common in elderly people, as in them this portion of the bone has undergone a certain amount of rarefaction. Many of the higher fractures of the surgical neck, however, pass in some part of their extent along the line of the anatomical neck, and in them symptoms may closely resemble those of this variety. Such cases are more likely to occur in young adults, and may even in part be a separation of the upper epiphysis.

The lesion is nearly always due to direct violence, such as blows or falls upon the tip of the shoulder. A portion, at any rate, of the fracture will always be within the joint cavity, so that considerable effusion is caused. Owing to this, and the inaccessibility of the separated portion, a large number of these cases have been overlooked.

In elderly people the fracture is often impacted, the lower portion being driven into the upper. If not impacted, the upper fragment may be freed from all periosteal and synovial attachments, and then often shows marked rotation (Fig. 31), which may be so extensive that the articular surface looks either upwards or downwards, or in some extreme cases directly outwards. The shaft is at the same time drawn somewhat upwards.

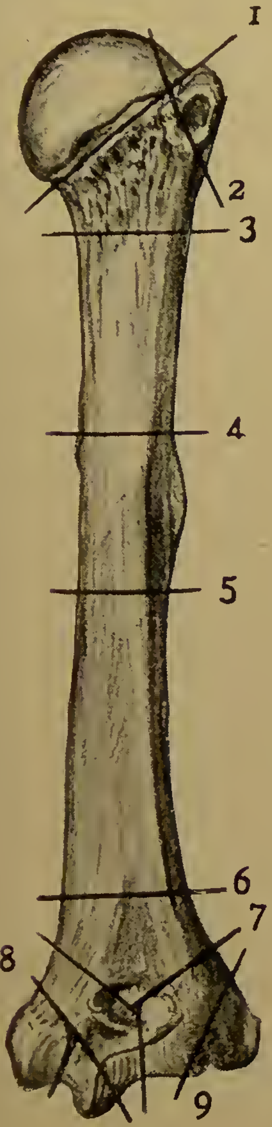

FIG. 30.—HUMERUS, SHOWING SITES OF FRACTURE.

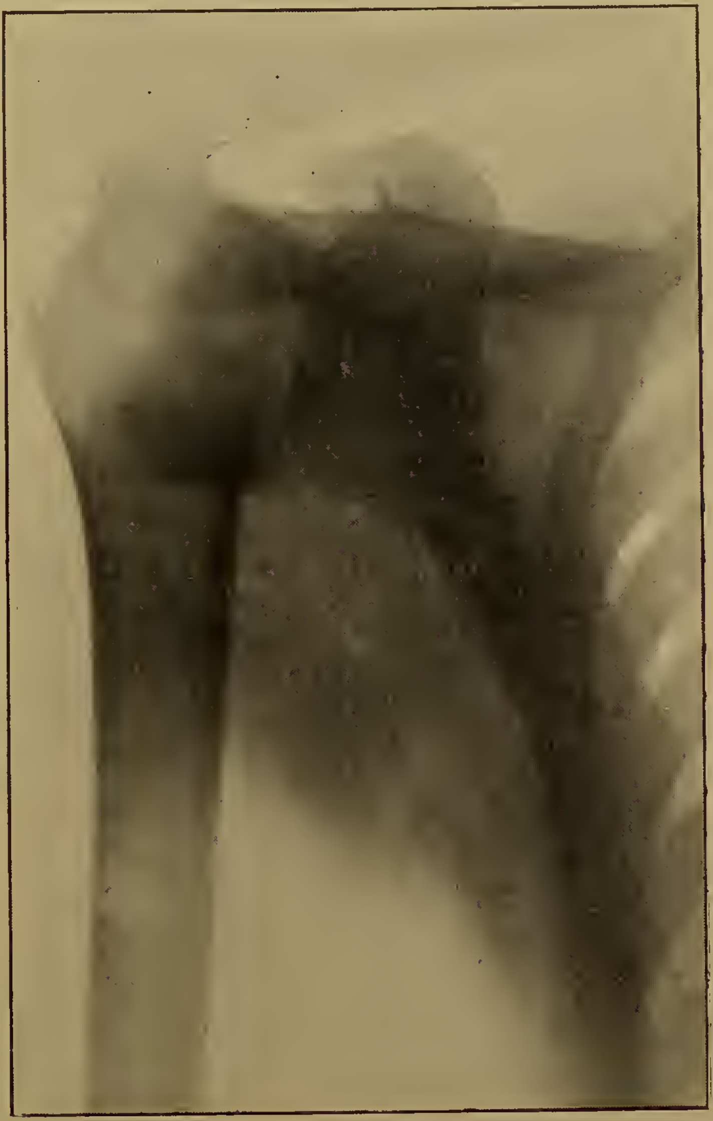

FIG. 31.—FRACTURE OF ANATOMICAL NECK OF HUMERUS, WITH ROTATION OF UPPER FRAGMENT. (Mr. Dean's Case.)

Symptoms.—There will be much pain and swelling in the affected shoulder, partly from the local trauma and partly from the effusion into the joint, so that the bony points are obscured. There is limitation of movement, accompanied by severe pain, abduction being the movement most at fault.

Unless impaction be present, crepitus will be felt high up, but may readily be mistaken for the creaking of an osteo-arthritic joint. In some cases abnormal mobility may be apparent in the upper part of the arm, and, if there be much displacement of the fragment, this may at times be felt from the axilla, but it is generally obscured by the effusion into the joint. The shoulder shows but little flattening, and may even be more prominent from the upward displacement of the shaft.

If impaction has occurred, a broadening of the upper part of the bone may be distinguished, crepitus will be absent, and the shoulder may be slightly flattened. The diagnosis is, however, so often obscure that all cases of doubtful injury to the shoulder should be radiographed, lest this injury be overlooked.

Treatment.—If there be impaction and but little displacement, care should be taken that the impaction is not broken down. A pad should be placed in the axilla, and the arm carefully bandaged to the side, so as to prevent all movement in the joint. Evaporating lotions may be applied to the shoulder to limit effusion; later warm moist applications will decrease the pain and aid in the absorption of the effused fluid. From the fifth to the seventh day passive movements should be gradually begun. For the first week these should be backward and forward movements; after this date careful abduction and rotation may be commenced. At the end of ten days gentle massage may also be given, and active movements allowed at the end of four weeks. Union should be good at the end of six weeks, but some pain and limitation of movement, especially abduction, is likely to persist, partly owing to the callus, and partly to osteo-arthritic changes set up.

If there be no impaction and but slight displacement, the arm must be more carefully immobilized. A ∩-shaped axillary pad (see Fractures of Surgical Neck) should be carefully moulded and applied. A poroplastic shoulder cap, reaching nearly or quite to the elbow, is also fitted. The arm is then bandaged to the side. Gentle massage may be started on the third day, but passive movements should not be commenced until after three weeks, and they must then be very limited. The splints are not left off until four weeks, by which time firm union has usually occurred. A prolonged after-course of massage and passive movements may be required before free movements can be performed, unassociated with pain.

If there be marked displacement of the upper fragment, as shown by a radiograph, or in some cases of impaction with severe deformity, especially in younger patients, an open operation should be undertaken. A vertical incision may be made over the outer surface of the shoulder, the fibres of the deltoid being separated; or it may be preferable to follow the anterior border of the deltoid, the line of incision corresponding to that used for excision of the shoulder. Attempts

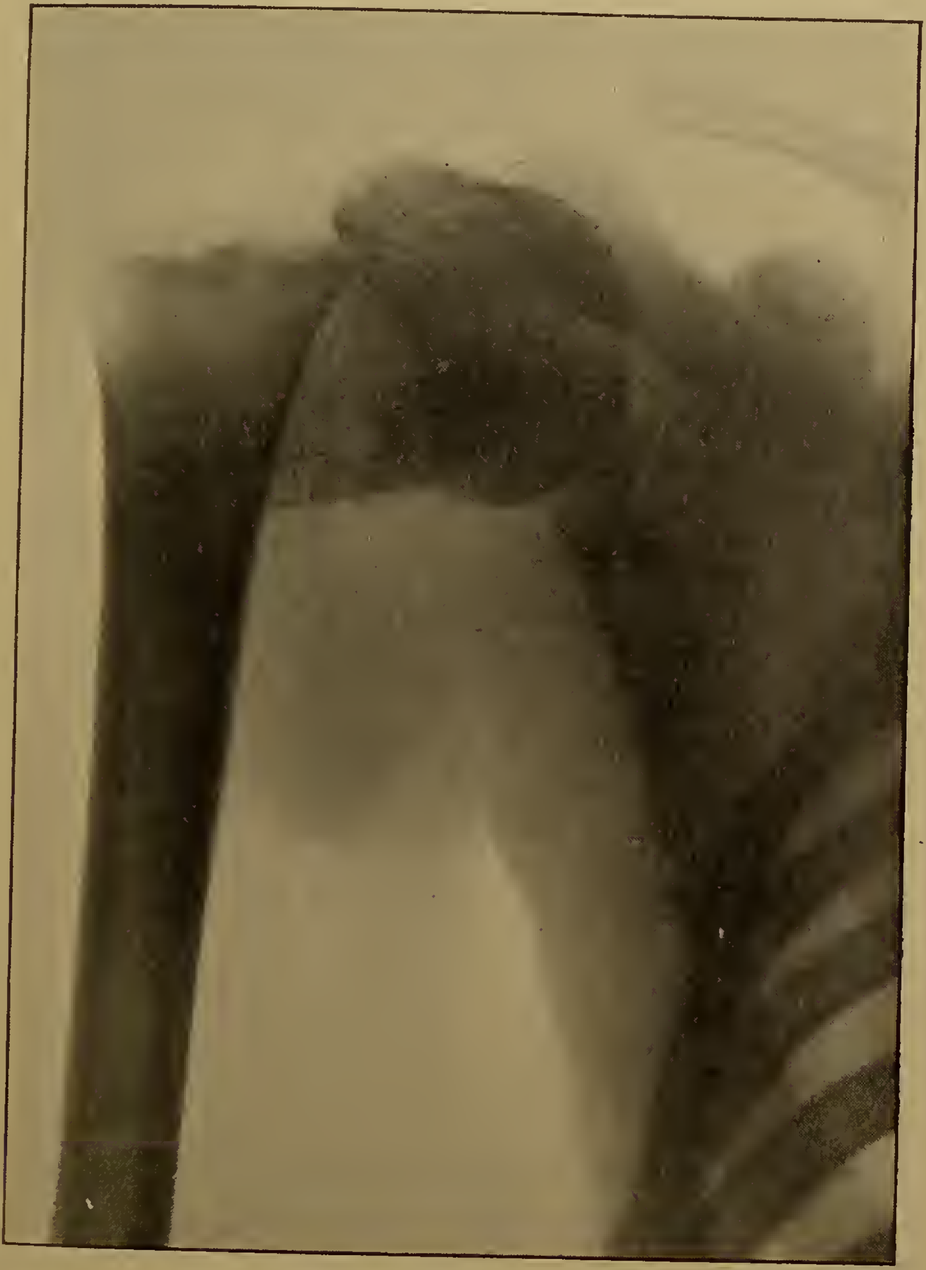

FIG. 32.—HIGH FRACTURE OF SURGICAL NECK OF HUMERUS. (Mr. Openshaw's Case.)

are now made to overcome the deformity by extension of the abducted arm, the fragments when in apposition being best joined by a screw or peg passing through the tuberosities and entering the head.

Care must be taken that this latter portion is not perforated. The wound is now closed, and massage and passive movements commenced in a few days. Rarely it may be necessary to remove the head entirely, in which case the upper part of the shaft must be carefully rounded, passive movements being commenced early and persevered with.

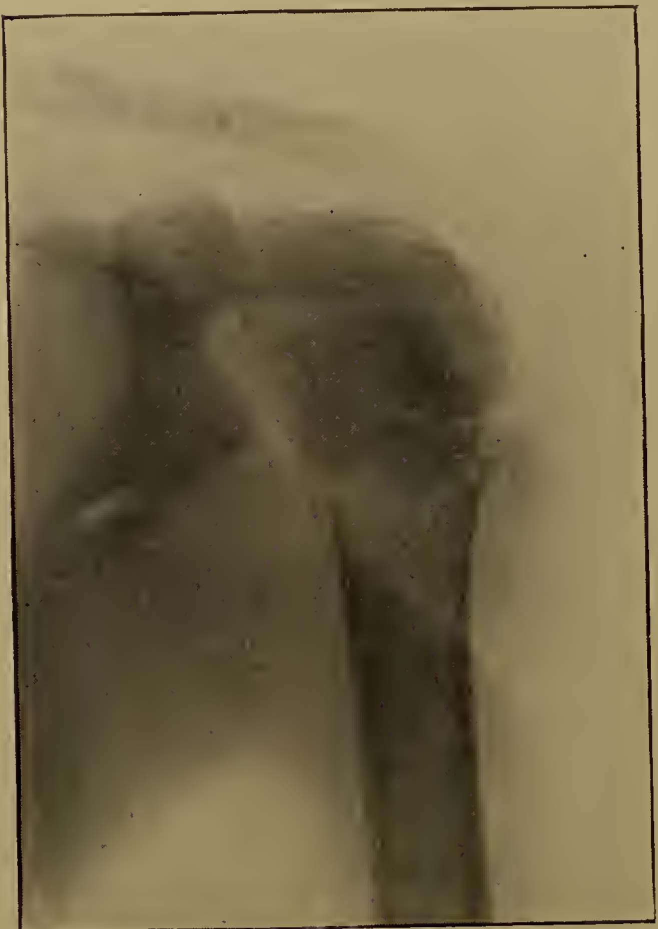

Fig. 33.—Low Fracture of Surgical Neck of Humerus, showing External Rotation of Upper Fragment. (Mr. Dean's Case.)

The Surgical Neck [3].—This is the most common fracture of the upper end of the humerus. For practical purposes two types may be recognized, the one high up (Fig. 32), due to the same causes as, showing the same displacement as, and often associated with, a separated epiphysis. As already mentioned, it may in part be a fracture of the anatomical neck. It will be considered further below.

The other variety occurs lower down, and generally shows a different displacement. It may be due to direct violence upon the arm below the level of the joint, or, more commonly, from falls upon the outstretched hand or elbow. The fracture is more or less transverse, taking place below the tuberosities, but above the bicipital groove. The upper fragment maintains its position within the glenoid cavity.

It is often rotated out by the action of the supraspinatus, infraspinatus, and teres minor muscles attached to the greater tuberosity (Fig. 33). This rotation may be slight, owing to the counteraction of the subscapularis. It is also generally somewhat abducted, the articular surface looking more downwards than usual.

The lower fragment is drawn inwards by the muscles attached to the bicipital groove (Fig. 34), and upwards by the long muscles of the arm. More rarely it may be displaced outwards.

Symptoms.—There will be much pain and effusion. At first sight the condition may be mistaken for a dislocation, owing to the arm being abducted from the side, but the flattening will be below, and not at the shoulder. The upper fragment may be felt below the acromion, and beneath this is felt a marked depression. There will be complete loss of function of the arm, especially abduction, the fulcrum around which this movement takes place being absent. The upper end of the lower extremity may be felt beneath the skin of the outer wall of the axilla, and in this position may cause pain running down the arm from pressure upon the brachial plexus, or the axillary vessels may be lacerated. The circumflex nerve may rarely be injured. Crepitus can be obtained if the two ends do not completely overlap, and if impaction be absent. The condition will be well shown by radiography.

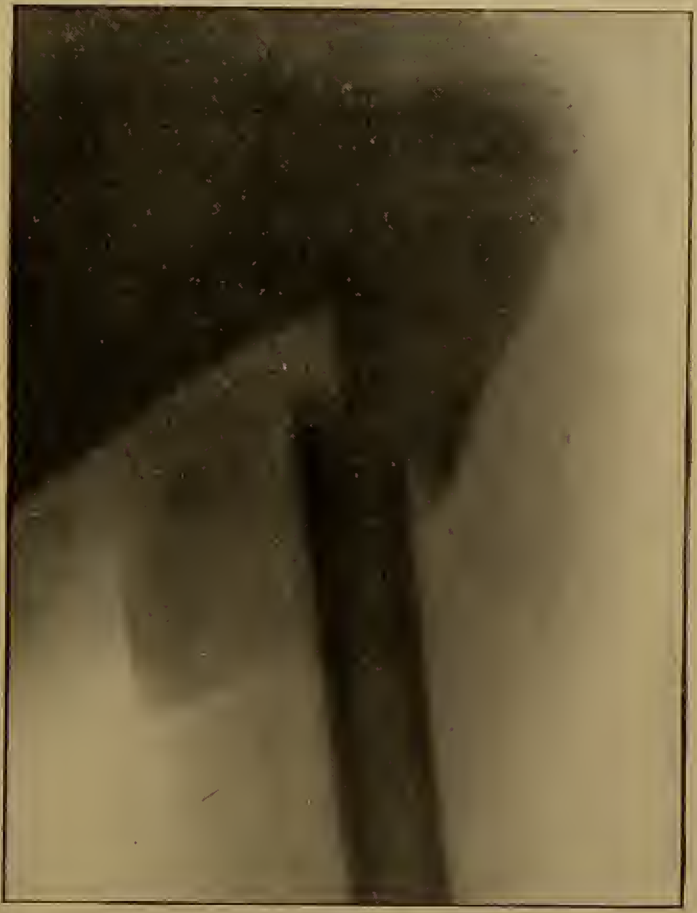

FIG. 34.—LOW FRACTURE OF SURGICAL NECK OF HUMERUS, SHOWING INWARD DISPLACEMENT OF LOWER FRAGMENT.

This type of fracture may at times be associated with a dislocation of the upper fragment, either one or other of the lesions being then commonly overlooked. For this reason all such cases should if possible be radiographed.

Treatment.—If there be no displacement, absolute fixation will alone be necessary in the early stages. A large pad is made to fit the axilla. This may be composed of cotton-wool or Gamgee tissue, and in this case should be made somewhat narrower above than below, and should be deep enough to reach to the internal condyle, so that the upper arm is comfortably supported upon it. Better even than this is a ∩-shaped pad made of poroplastic material to fit the side of the chest and arm (Fig. 35, A). This must be carefully padded with cotton-wool freely dusted with boric acid powder. In either case a poroplastic shoulder cap is also made. This must be large enough to firmly fix the shoulder. It should be cut to fit round the neck, reach to the middle line of the chest and back, and pass down as far as the nipple. It should encircle the outer half of the arm, nearly as far as the condyles (Fig. 35, A). This must also be carefully padded, and as the swelling decreases will probably have to be altered. These two poroplastic moulds may be fixed by straps passing round the chest, arm, and axilla. In their simpler forms they may readily be made by the surgeon. The forearm is now brought up across the chest, the fingers reaching to the opposite clavicle, and separated from it by a layer of dusted cotton-wool. The whole arm is firmly bound to the trunk with a bandage. On the third day the shoulder

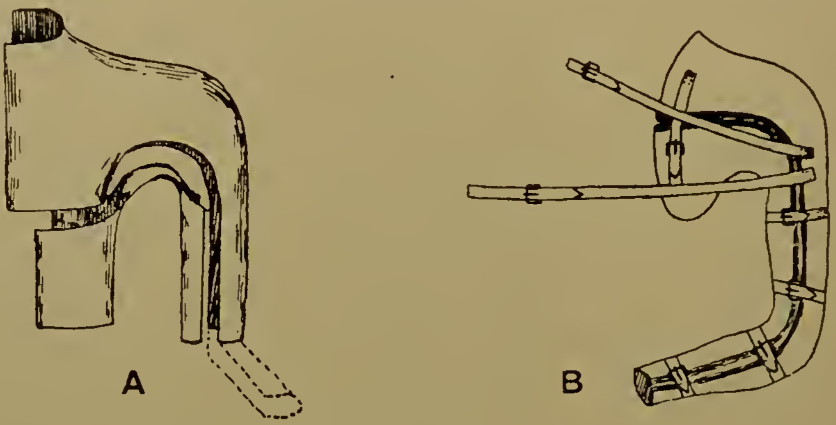

FIG. 35.—POROPLASTIC SPLINTS.

A, Axillary pad and shoulder cap. Dotted lines show extension to be added where external rotation of lower fragments is required. B, Single piece splint for fractures of shaft.

cap may be removed and gentle massage applied, the axillary pad being kept in position. At the end of three weeks the poroplastic splints may be removed and gentle passive movements commenced, the splints afterwards being replaced. At the end of four weeks they may be discarded, the arm being bound to the side for another week. Massage and passive movements are continued for three to four weeks more.

If the upper fragment be rotated outwards, it will be necessary to bring the lower fragment into apposition with it. This will be accomplished if the hand, when the elbow is flexed to a right angle, be made to point directly forwards instead of lying on the front of the chest. Fixation of the hand in this position is somewhat difficult, and is best attained by prolonging the poroplastic splint downwards so as to encircle the forearm and fix it in this position. The fashioning of such a splint is difficult, and it is best to have one made by an instrument-maker (see Poroplastic Splints, p. 30).

Such a splint will consist of a shoulder cap and a long armpiece reaching to midway along the metacarpal bones. The arm will be fixed to the side, the elbow flexed, and the hand will point directly forwards. It may be strengthened by steel bars. The upper arm should in addition be bandaged to the side. If the splint be made in two parts—*i.e.*, a shoulder cap and an axillary pad—massage may be begun, as in the last case, on the third day, the axillary splint not being removed. Passive movements should be deferred until three weeks after the accident. The after-treatment will be similar to the last variety.

If the lower fragment be displaced inwards and upwards, the deformity should, if possible, be reduced under an anæsthetic. If this fails, as it often will, the patient should be kept in bed, an extension apparatus applied from the wrist to the axilla (p. 20). The arm must be fully abducted and extended by a weight passing over a pulley attached to the side of the bed, the body being fixed by a wide strap passing round the chest and scapula, and fastened to the opposite side of the bed. The weight should at first be about 3 to 6 pounds, according to the patient's age, and should be increased to as much as the patient can stand without pain.

If replacement does not occur spontaneously at the end of a week or ten days, manipulation under an anæsthetic should again be tried. Even if reduction is brought about, the extension must again be applied until the end of three or four weeks, to prevent recurrence, when union should be firm. A sling is then worn for another two weeks. Massage should be commenced on about the third day.

In many cases, especially where there is marked overlapping, it will be impossible to overcome the deformity by any of the above methods. An open operation should then be performed. An incision 4 to 5 inches long is made along the anterior border of the deltoid, this muscle fully retracted, and the ends brought into position by extension exerted by an assistant, aided by leverage on the part of the surgeon. The two fragments are now fixed. This may be accomplished either by wiring or by the use of plates and screws. The arm is then supported as above, massage and passive movements being commenced as soon as the wound is healed. If dislocation be present an open operation will also be required, the two fragments being fixed either before or after reduction (see Complications).

Laceration of the vessels must be treated by immediate operation, which, owing to the extent of the hæmorrhage, is often fraught with great difficulty. The subclavian artery should be compressed, and the bleeding vessels cut down upon. If possible, the openings are sutured or the ends anastomosed. If this fail both ends must be ligatured. Ligature of the third part of the subclavian is insufficient, as hæmorrhage from the distal end may continue owing to the free collateral circulation.

Separation of the Upper Epiphysis.—The upper end of the humerus is developed from three centres—one for the head, which appears six months after birth; one for the great tuberosity, which appears in the second year; and a third for the lesser tuberosity, appearing in the third year (Fig. 36). Those for the head and great tuberosity join in the third year, the lesser tuberosity uniting with them at the seventh year. Thus a single epiphysis is formed, which does not unite with the shaft until the twenty-fifth year. After the age of twenty union is so firm that separation practically never occurs, it being replaced by a fracture of the surgical neck or by a dislocation. Separation is very rare before the age of six or seven. If it occurs, the whole growing end is displaced (Fig. 37), separation of the individual centres being almost unknown. The periosteum is firmly attached to the epiphyseal line, so that in some cases the displacement is slight. This may also possibly be due to the fact that the upper end of the diaphysis is conical, and the central projection hitches against the edge of the epiphysis. With such slight displacement the joint will probably not be opened, the attachment of the synovial membrane to the diaphysis being very loose. In other cases the end of the diaphysis may puncture the periosteum, which will then lie between the two fragments, and make reduction difficult or impossible (J. Hutchinson junior).[1]

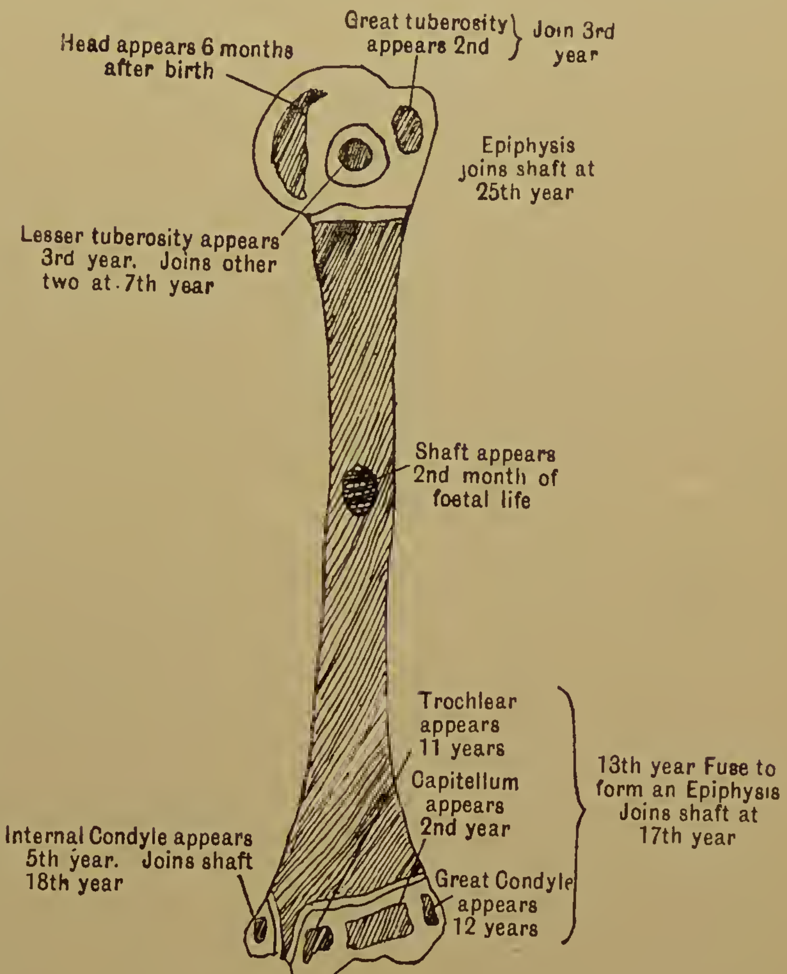
Head appears 6 months after birth
Great tuberosity appears 2nd
Join 3rd year
Epiphysis joins shaft at 25th year
Lesser tuberosity appears 3rd year. Joins other two at 7th year
Shaft appears 2nd month of foetal life
Trochlear appears 11 years
Capitellum appears 2nd year
13th year Fuse to form an Epiphysis Joins shaft at 17th year
Internal Condyle appears 5th year. Joins shaft 18th year
Great Condyle appears 12 years

FIG. 36.—OSSIFICATION OF HUMERUS.

More commonly, however, the periosteum is much torn, and the two fragments are freely separated. The line of separation is not as a rule limited to the epiphyseal line. In the outer part a portion of the diaphysis is often torn off, and is displaced with the epiphysis (Fig. 37), so that it is often impossible to say whether separation of the epiphysis or a high fracture of the surgical neck be present. Both types of injury are alike as regards their cause, displacement, and treatment.

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[1] *Brit. Med. Journ.*, July 16, 1887.

Separation may be caused either by direct or indirect violence, the latter being the more common, and similar in nature to that producing dislocation of the shoulder in adults —*i.e.*, falls on the hand or elbow. In fact, J. Hutchinson says: "Generally before the age of twenty separation of this epiphysis takes the place of dislocation."

The upper fragment will undergo the same displacements as occur in a fracture of the surgical neck (p. 122). The lower may pass inwards, and occupy the same position as in a subcoracoid dislocation. It seems, however, more common in these cases, as in fracture of the surgical neck high up, for the lower fragment to be displaced outwards and upwards (see Figs. 37, 32), and to form a marked projection beneath the skin.

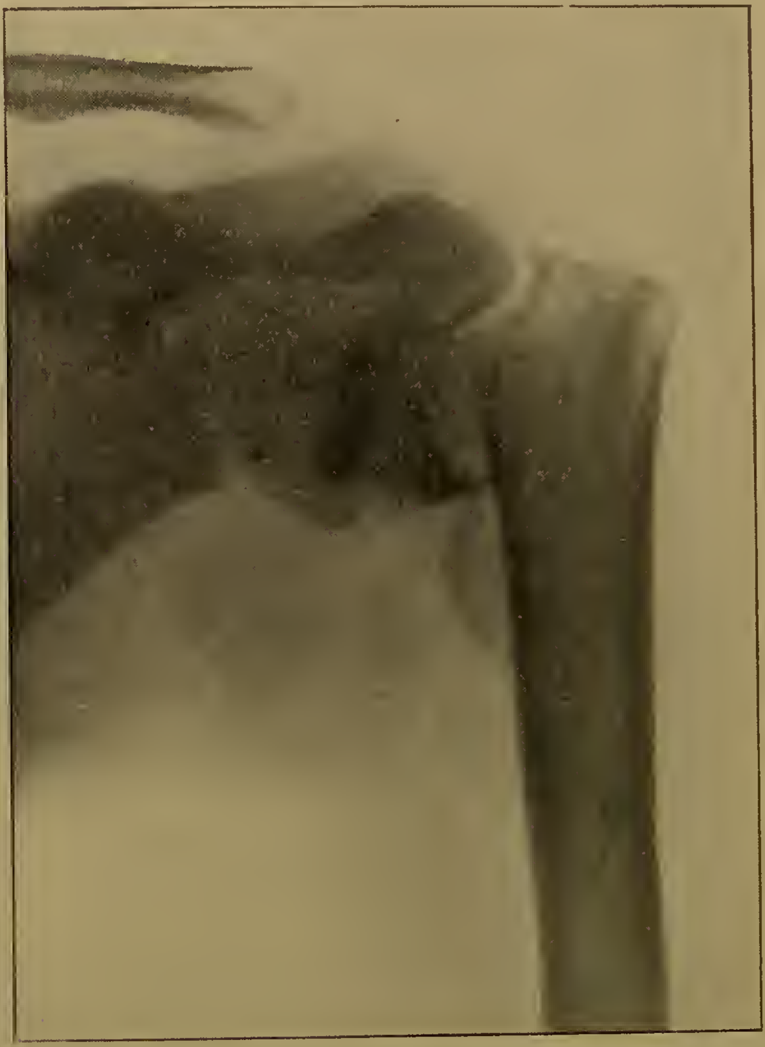

FIG. 37.—SEPARATED UPPER EPIPHYSIS OF HUMERUS.
(Mr. Rigby's Case.)

Symptoms.—There will be pain and swelling of the shoulder, with limitation of the movement. If the lower fragment project outwards, the shoulder will be widened, and a sharp and very evident prominence be present outside the tip of the shoulder. The head of the bone will be felt in the glenoid fossa, and will not rotate with the shaft. If the lower fragment be displaced inwards, the condition will resemble somewhat a dislocation. The elbow will be away from the side, a depression will be seen and felt beneath the shoulder, whilst the lower fragment may be felt, or even seen, beneath the skin in the subcoracoid position. In either case the arm will be shortened. If the displacement be incomplete, the deformity will not be so marked. There will then be swelling, loss of function, especially abduction, increased mobility below the shoulder, also best shown on movements of abduction, and a soft crepitus high up. The movements made to obtain this will not be associated with movement of the upper fragment.

Rarely, with much displacement, the end of the diaphysis may perforate the skin, whilst the variety with inward displacement may be associated with pressure upon the brachial plexus or vessels. Injury of these structures is more rare than in the case of fracture, owing to the relative smoothness of the end of the diaphysis.

Treatment.—If there be no displacement, the arm must be immobilized, as soon as possible, by the means adopted for a fracture of the surgical neck. If this be not done, subsequent displacement may occur. If displacement be present, it is essential that this be overcome, or a great decrease in the growth of the bone will result. This may be attempted by manipulation and weight extension with the patient in bed, the muscles being relaxed by the use of massage, as in a case of fracture of the surgical neck. If, after a short trial, this fail, open operation should soon be resorted to. An incision is made along the anterior border of the deltoid, firm traction made upon the arm by an assistant, and attempts made to lever the fragments into position. When this is accomplished, fixation by wiring will not as a rule be necessary, owing to the conical shape of the diaphyseal end. Rarely it may be necessary to remove a portion of the diaphysis in order to bring about approximation. The after-treatment will be similar to that of a fracture of the surgical neck.

Separation of the Great Tuberosity [2].—This is most commonly seen in cases of subcoracoid dislocation of the humerus. The external rotators of the shoulder are here forcibly stretched around the glenoid cavity. This may be sufficient to tear off the tuberosity, the arm then being rotated inwards (intracoracoid variety of Malgaigne). An interesting case throwing light upon this condition has been published by Gibbons,[1] of separation of the tuberosity from muscular violence without dislocation. At times it may be caused by direct violence to the shoulder, the projecting tuberosity being knocked off. This may then be the only lesion present, or it may be accompanied by a fracture of the surgical neck. The fragment will be drawn backwards by the action of the supra- and infraspinati and the teres minor, whilst the rest of the humerus is rotated inwards by the unopposed action of the subscapularis.

Symptoms.—If occurring with a dislocation, the condition is likely to be overlooked after the dislocation is reduced, and therefore a radiograph should be taken. The tuberosity may be felt to be separated by a distinct groove, while crepitus may be obtained on moving the fragment. The shoulder will be widened from the backward displacement of the separated tuberosity, and the rest of the arm will be rotated inwards.

Treatment.—Excepting in elderly people with a subcoracoid dislocation, open operation should be advised, as this is the only method likely to give good union. An incision is made directly over the fragment, the rest of the arm rotated out, a hole drilled through the fragment and the shaft, and the two fixed with an ivory peg or screw. Passive movements may be commenced after a week, no splint being required. Attempts to obtain union by fixing the arm in a position of full external rotation are likely to fail, and are very uncomfortable for the patient.

THE SHAFT.

Fractures of the shaft are common, and may occur from direct or indirect violence, usually the former, in which case the line of fracture tends to be transverse, and may be situated at any portion of the shaft. Those due to indirect violence, such as blows upon the hand or elbow, tend to be oblique, while if caused by rotatory violence, such as during attempts to reduce an old dislocation or from forcible twisting of the arm, as may be done by one schoolboy to another, a spiral fracture may result.

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[1] *Brit. Med. Journ.*, December 11, 1909.

In some cases a fracture may be caused by excessive muscular violence, as when an object is thrown with great force. The displacement and treatment will vary according to the position of the fracture.

In the Upper Third [4].—The line of fracture here will be situated above the insertion of the deltoid. The upper fragment will be drawn in by the muscles attached to the bicipital groove. The upper end of the lower fragment will be pulled outwards by the deltoid, and upwards by the contraction of the long muscles of the arm, so that the two fragments will markedly overlap (Fig. 38).

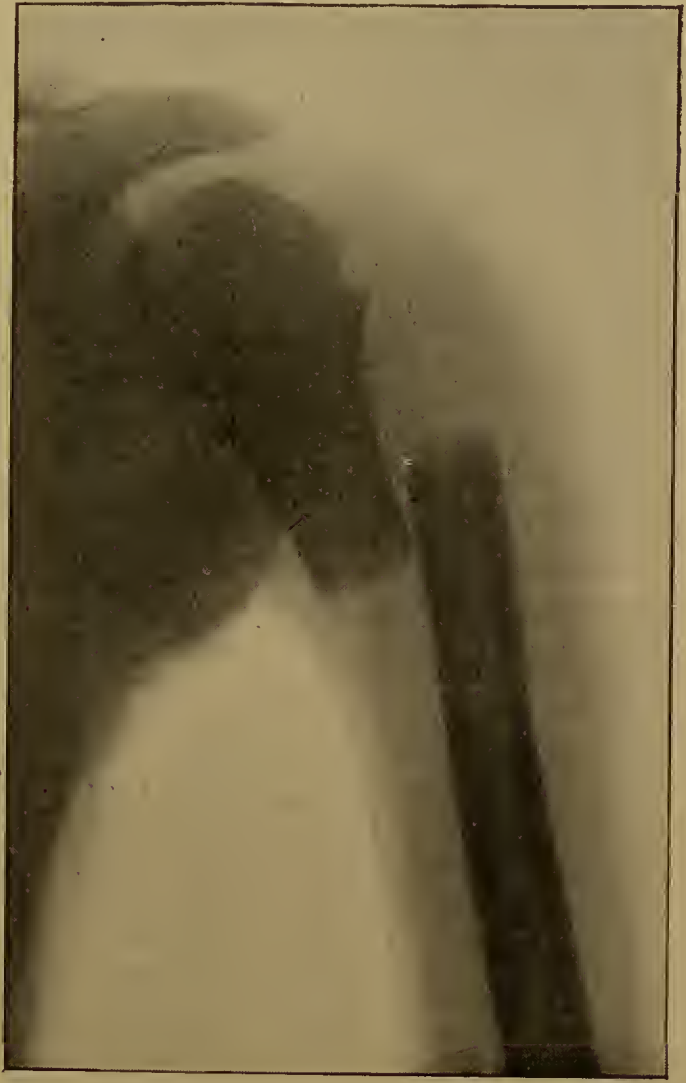

Fig. 38.—Fracture of the Shaft of the Humerus above the Insertion of the Deltoid: Lower Fragment displaced outwards. (Mr. Dean's Case).

Locally there will be pain and swelling, the arm will be visibly shortened, and measurements taken between the spine of the acromion and the external condyle on the sound and affected sides will show this more definitely. The two ends of the bone may be felt in an abnormal position, and crepitus may be elicited.

This variety may occur in the newly-born from attempts to bring down an extended arm in breach presentation.

Treatment.—Any deformity should be overcome by manipulation and extension. Unless the patient be a strong muscular man, an anæsthetic will not generally be required for this purpose. It is often advised that the fracture be fixed by means of an internal angular and short external splints. By this means, however, it is impossible to fix the fragments, for the internal angular splint will only just reach to the level of the lesion. The arm and axilla having been cleansed and thoroughly dusted, a pad is placed in the axilla. This should be wider below than above, being about $1\frac{1}{2}$ inches thick in the axilla, and $2\frac{1}{2}$ inches at its base. It must be long enough to reach to the internal condyle. The ∩-shaped poroplastic splint figured on p. 124 will be most useful here, but it should be made with an armpiece long enough to reach to the internal condyle. It is fixed with straps before the other splints are placed in position. Two short wooden splints or a piece of Gooch's splinting should now be fixed to the outer side of the arm with straps. Instead of these, a shoulder cap, fashioned as for fractures of the surgical neck, may be used. The upper arm is now bandaged to the side, and the forearm flexed and placed across the chest, where it is held in position by a sling. This sling must only pass round the wrist. If passed under the elbow too, the lower fragment will be pushed up and the overlapping increased. After three or four days the outer splints or shoulder cap are removed and gentle massage commenced. In two weeks passive movements of the shoulder and elbow are begun, the fragments being at first supported with the other hand, and the splints replaced until the end of four weeks, after which it is only necessary to wear a sling. This may be discarded two weeks later.

If overlapping persist in spite of this method of treatment, the arm may be put up on a Middledorf's triangular splint, by means of which a certain amount of extension can be applied; but, owing to the high level of the fracture, it is not so successful as in the next variety. Should it fail, the patient should be placed in bed, and continuous extension applied by means of a weight and pulley, as advised for fractures of the surgical neck. Under no circumstances should the patient be allowed to walk about with a weight hanging from the elbow. Under these conditions the weight will swing irregularly, and excessive movement of the lower fragment take place, whereby non-union will be very likely to occur. The extension should be aided by manipulation under an anæsthetic, and should be maintained for three weeks. In some cases, where there is marked deformity, especially in cases of oblique or spiral fractures, the above methods will fail, and an open operation will be necessary.

An incision along the anterior border of the lower part of the deltoid will generally be most convenient, or one may be made over the outer side of the arm. It should be at least 4 to 5 inches long. The muscles being held aside with retractors, the ends of the bone are bared, cleaned, and freshened, then manipulated into position, extension being made on the forearm. They may be fixed by the use of wires or metal plates and screws, the former being more satisfactory for oblique fractures, the latter for transverse.

The limb should be fixed in a splint for two weeks, and massage and passive movements commenced at the end of that time, the splints being replaced until the end of three and a half to four weeks.

In the newly-born the arm may be simply bound to the side, or fitted with a splint made of cardboard well covered with cotton-wool. It should be kept in place for about two weeks.

In the Middle Third [5].—In this case the line of fracture will be situated below the insertion of the deltoid. The upper fragment, therefore, will be drawn outwards by this muscle, while the lower is drawn up on its inner side by the contraction of the long muscles of the arm (Fig. 39). For this reason the vessels of the arm are likely to be injured. The lesion in the bone also crosses the musculo-spiral groove, generally in that part of its course lying posterior to the bone. The nerve may therefore be injured at the time of the accident, or later is prone to be involved in the callus.

Scudder and Paul[1] have collected the statistics of this complication in 1,185 cases of fracture of the humerus. The musculo-spiral nerve was injured eighty-six times. Of

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[1] *Annals of Surgery*, December. 1909, p. 1118.

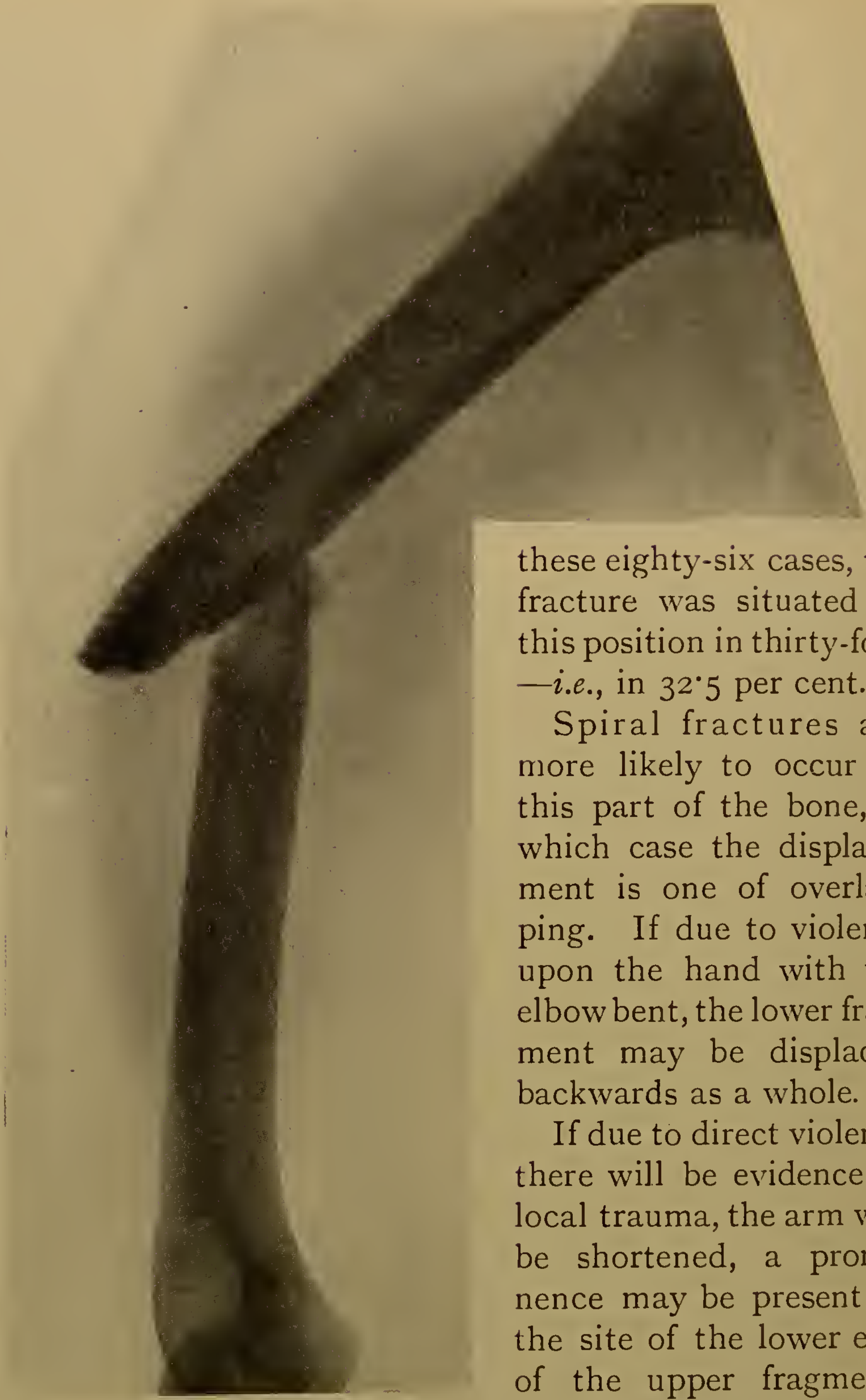

FIG. 39.—FRACTURE OF SHAFT OF HUMERUS BELOW THE INSERTION OF THE DELTOID: UPPER FRAGMENT DISPLACED OUTWARDS. (Mr. Furnivall's Case.)

these eighty-six cases, the fracture was situated in this position in thirty-four —*i.e.*, in 32·5 per cent.

Spiral fractures are more likely to occur in this part of the bone, in which case the displacement is one of overlapping. If due to violence upon the hand with the elbow bent, the lower fragment may be displaced backwards as a whole.

If due to direct violence there will be evidence of local trauma, the arm will be shortened, a prominence may be present at the site of the lower end of the upper fragment, and beneath this a well-marked depression. Crepitus can generally be obtained, unless there be much overlapping, or unless portions of the triceps or brachialis anticus be displaced between the fragments, as may occur with oblique fractures.

Treatment. — For simple cases the best results will be obtained by the use of Middledorf's triangular splint (Fig 40). This consists of three pieces of wood hinged together to form a triangle. The base of the triangle fits along the side of the body, and should reach from the axilla to the crest of the ilium. The other two sides project out from this at an angle, to meet in the bend of the elbow. Each side is from 3 to 4 inches wide, and all three sides must be well padded. They are usually hinged at the upper and outer angles, the lower side moving up and down on the inner at the inferior angle, so that the size of the splint may be altered within certain limits. When in use, the base of the triangle is fixed to the side of the patient by straps passing round the body and over the opposite shoulder. The upper arm will then lie flat upon the upper and outer side of the triangle, so that the lower fragment is brought into line with the upper, and both lying on the same flat surface, lateral displacement will alone have to be corrected.

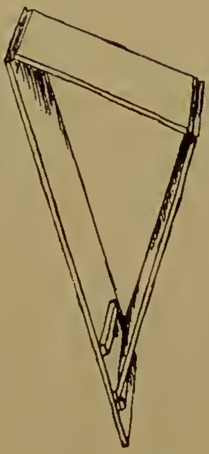

FIG. 40.—MIDDLEDORF'S TRIANGULAR SPLINT, UNPADDED.

The forearm lies along the inferior side, and by placing a pad at the bend of the elbow the lower fragment can, if necessary, be extended by simply bringing the forearm down to the splint, the pad acting as a fulcrum.

This splint gives very good results, is very comfortable, and is best worn when the patient is walking about. The objection to its use is that, when it is once in position, it is difficult to get the patient's clothes on and off, but with a little ingenuity this can usually be overcome. The splint should be kept in position for four weeks, daily massage being commenced on about the fourth day, and passive movements of the hand and elbow at the end of ten days, and of the shoulder at the end of two weeks, the ends beings held in position. At the end of four weeks the splint is replaced by a sling.

A poroplastic axillary pad and shoulder-piece, which should be prolonged down to the wrist, may be used here in a manner similar to that for fractures of the upper third, or, what is often better when the fracture is as low as this, a poroplastic jacket for the arm extending on to the shoulder and chest (Fig. 35, B). This is divided down the front to allow the arm to be placed in it, and accurately fits the limb when deformity is overcome, the measurements being taken from the sound side. It must be made by a skilled intrument-maker, and, having been softened by steaming, is applied with the patient under an anæsthetic. The upper part of the arm is fixed by straps passing across the shoulder, and the lower arm is supported in a sling.

Rushton Parker[1] advises that these fractures, as indeed all between the clavicle and the elbow, should be treated by simply slinging the hand around the neck, whereby the deformity is overcome by the weight of the elbow, and the backward displacement by the flexion of the elbow. It is far safer, however, to combine the flexion with the use of poroplastic axillary and shoulder splints, as advised in the case of the higher fractures of the shaft. The flexion will then overcome any backward displacement, whilst the fixation prevents undue movements on the part of the patient and the tendency to recurrence which takes place when he lies down. An internal angular splint with short external splints is often advised here, but in these cases also it will be extremely difficult by this means to fix the upper fragment, and thus non-union, which is common in this position, is likely to follow.

In some cases extension by a weight and pulley may be required, as in fractures of the surgical neck.

If it be impossible by any of the above means to obtain apposition, or if the vessels be injured, an open operation is required. In the former case a vertical incision 4 to 5 inches long should be made on the outer side of the arm, the triceps and brachialis anticus being separated. In the latter case it is made on the inner side of the arm over the injured vessels. Any adventitious structures are removed from between the ends, and the fragments fixed by wires or plates. The limb is then supported on splints, as in the simple varieties.

All cases should be examined at the time of the accident for evidence of the involvement of the musculo-spiral nerve, as shown by wrist-drop and paralysis of the extensors and supinator longus. If this be present, an open operation should be undertaken. The nerve must be cut down upon, the ends found, freshened, and sutured with catgut. A vertical incision directly over the groove will be most useful for this purpose. The fragments should at the same time be fixed. If signs of paralysis develop late from pressure of callus, an operation must be undertaken immediately, as this condition is progressive. Excess of callus is removed, the nerve freed, and if in part destroyed, this area excised, the ends being then sutured. The line of suture should be surrounded by Cargile membrane. After suture of this nerve the hand must be supported on a splint to extend the wrist, and regular massage given to the affected muscles until they have completely recovered, which will usually be the case in about nine to twelve months.

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[1] *Trans. Roy. Med. Soc.*, July, 1908, Surg. Sect., p. 221 *et seq.*

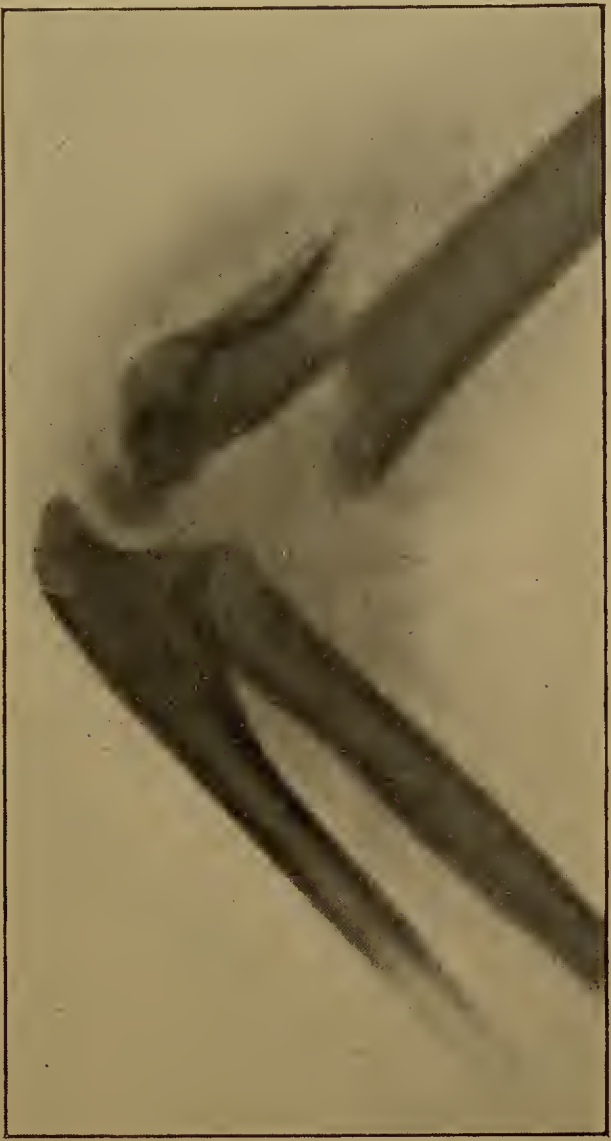

FIG. 41.—SUPRACONDYLAR FRACTURE OF THE HUMERUS. (Mr. Rigby's Case.)

Of the Lower Third [6].—Fractures of this portion of the shaft may be due to direct or indirect violence, and usually take place just above the condyles. Most commonly they are caused by falls upon the hand with the elbow flexed to a right angle, in which case the lower fragment is displaced backwards, or from falls upon the point of the elbow, when the fragment comes forward. In some cases there may be lateral displacement. In either instance, when once the alignment of the two fragments is altered, shortening takes place, the lower end being drawn upwards (Fig. 41).

Of more importance still are the rotatory displacements.

Generally the lower fragment is flexed upon the ulna, this amount of flexion being greatly increased when the arm is fully extended.

This displacement is of great importance in that it is very common, and if overlooked, as it often is, there will be marked limitation of flexion after union has occurred. This is due to the fact that, when full flexion has occurred at the joint, the lower fragment being tilted brings the forearm into a much more extended position. Lateral deviations of the axis of the limb are not as common in this type of fracture as in those involving the joint.

Symptoms.—There will be much pain and swelling of the affected elbow, the patient supporting the wrist in the unaffected hand. The local deformity will vary according to the position of the lower fragment, and will resemble somewhat the different types of dislocation. Thus, if the fragment is displaced backwards, the elbow will be very prominent behind. Above this is a deep depression, and it can usually be easily made out that this depression is well above the joint, the normal relationships of the olecranon and the two condyles of the humerus being maintained. The length of the upper arm as measured from the spine of the acromion to the external condyle will be shortened, but there will be no alteration in the distance between the external condyle and the styloid process of the radius. By these means this injury may be distinguished from a dislocation backwards. The deformity may also be more readily reduced with the presence of crepitus.

The lower end of the upper fragment may form a prominence in front of the elbow. In the less common varieties, with displacement forwards or laterally, the deformity will be different. Thus, in the former there will be a prominence behind and above the elbow, corresponding to the lower end of the upper fragment, the lower fragment forming a prominence in front. In the latter the upper fragment will project on the inner or outer side above the joint. It may at times perforate the skin. Movements of the elbow-joint will be much limited, and accompanied by severe pain. Abnormal mobility can be readily felt in the lower part of the shaft.

Treatment.—Attempts to overcome the deformity by direct extension upon the forearm will usually fail. When the elbow is thus extended the lower fragment is flexed, and in the common variety becomes hitched up against the lower end of the upper fragment. Reduction should always be attempted under an anæsthetic. The forearm is then fully flexed, and extension applied to the elbow with the arm in this position. By this means the deformity can usually be overcome. There is, however, a great tendency for it to recur. This is much best prevented by putting up the arm in a fully flexed position, whereby the rotation of the lower fragment is overcome, while the muscles of the arm and forearm, coming into contact, act as a fulcrum, the lower fragment being rotated forward round it. The bend of the elbow should be freely dusted with boric acid powder and covered with a thin layer of gauze or wool; the elbow is then bent up as fully as it can comfortably go. If there is much swelling, this flexion has to be incomplete at first, but is increased as the exudate is absorbed. The flexion is maintained by a strap passing round the wrist and upper arm above the prominence formed by the biceps. It should be applied over a layer of cotton-wool. A further layer of cotton-wool is placed between the arm and the chest, and the limb bandaged in position. Great care must be observed in guarding against pressure; thus, the limb must be examined every day for increase of the local swelling, for swelling of the fingers, and for the absence of the radial pulse. If the elbow be left uncovered, massage, at first very gentle and consisting only of rubbing movements, may be commenced on the second day. This will usually aid in the absorption of the exudate and allow the flexion to be increased. The parts must be kept clean and fresh powder and wool applied every second day, so that no excoriation occurs. At the end of ten days gentle passive movements may be commenced and regularly continued. Forward displacement of the lower fragment is also often best reduced by this method.

It is frequently advised that the backward and forward displacements be treated by posterior or anterior angular splints, with pads so arranged that the displaced portion is pushed into position. Thus, if the displacement be backward, a posterior angular splint would be applied with a pad behind the elbow, and a second one over the lower end of the upper fragment in front. This method, however, does not overcome the tilting of the lower fragment, which is one of the most important deformities.

In the case of lateral displacements, the deformity may be well overcome by applying an internal or external angular splint after the displacement has been reduced by manipulation under an anæsthetic. The splint should be well padded and dusted with boric acid, and should be fixed by straps over cotton-wool rather than by adhesive plaster. Massage with the splint in position may be commenced in two to three days, with gentle passive movements at the end of a week, the fragments being supported and the splints reapplied. The splint should be worn in all for three weeks, and after this a sling for one or two weeks. Massage and passive movements may need to be continued for some weeks, or even months, before perfect use is restored.

In every case a radiograph should be taken after the limb has been placed in position; and if the deformity has not been overcome, an open operation should be decided upon. The results of this are much better when undertaken early, before adhesions and excess of callus have had time to form.

Wallis[1] advocates open operation in all cases where there is limitation of movement, as this he regards as being due to rotation or lateral displacement of the fragments. A posterior incision 2½ to 3½ inches long will usually be found the most convenient. The triceps is split; the fragments are manœuvred into position and fixed with wires or plates. The limb is placed on an internal angular splint, and passive movements commenced in a few days, with massage as soon as the wound has healed.

THE LOWER EXTREMITY.

Fractures of the lower extremity of the humerus are nearly always due to direct violence. They are more common in young children, in them being often associated with a separation of the epiphysis. They are of great importance in that, owing to involvement of the joint and alteration in the line of the articular surfaces, considerable disability is likely to result. They may be considered as follows:

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[1] *Lancet*, February 29, 1908.

T- or Y-shaped Fractures [7].—These are a combination of supracondylar fracture of the shaft with a vertical split passing down into the joint. The vertical fracture will pass through the thinner part of the bone—*i.e.*, through the coronoid and olecranon fossæ—dividing the articular portion close to the junction of the capitellar and trochlear surfaces. The violence producing such a fracture may be severe or comparatively slight. The lower end of the bone is separated in the form of two fragments, which are displaced inwards and outwards, causing considerable widening.

Symptoms.—There will be a great increase in the amount of fluid within the joint, while the surrounding soft tissues are much infiltrated and bruised from the trauma. The arm will be kept in a position of semi-flexion, and midway between pronation and supination. The axis of the forearm may be much displaced either inwards or outwards, according to which of the two condyles is the most displaced upwards. Normally, when the arm is extended the olecranon and the tips of the condyles lie in the same straight line; when the arm is flexed they form an equilateral triangle. In these cases, if the bony points can be made out apart from the swelling, this normal relationship will be found to be disturbed. This is best felt by placing the thumb over the tip of the external condyle, the middle finger over the tip of the internal condyle, and the forefinger over the tip of the olecranon, the right hand of the surgeon being used for a fracture of the patient's left humerus, and the left hand for one of the right. The position of the three prominences is then easily determined both at rest and during movements of flexion and extension. In some severe cases the whole relationships of the bony points are altered, several loose fragments, freely moving beneath the œdematous soft tissues, being alone made out. In nearly all cases crepitus can be elicited. Movements at the elbow-joint, especially laterally, will be greatly increased.

In all cases a radiograph should be taken, so that the exact condition may be diagnosed.

Treatment.—In some cases of simple T- or Y-shaped fracture it may be possible to obtain good position by putting up the arm fully flexed, as advised in supracondylar fractures. This method must never be trusted, however, unless a radiograph shows that reposition is good. If successful, massage should be commenced on the second or third day, and very gentle passive movements, with the fragments supported, on the seventh or tenth days. Owing to the amount of swelling this method is often very difficult to adopt, even after reduction of all deformity under an anæsthetic, and it must be remembered that slight alterations in the articular surfaces may cause great disability. For these reasons the more severe cases, and those showing persistent deformity, should be treated by open operation. By this means separation of the fragments and rotation or lateral displacement of the lower part are easily overcome, while the perfect apposition gained prevents that excessive formation of callus which is so important a factor in limiting movement at a later date.

A vertical incision over the joint behind will usually be the most satisfactory. The fibres of the triceps are separated widely, the joint opened, all clot removed from it and the surrounding tissues, and the fragments brought into good position. The two lower fragments are fixed to one another by a wire, plate, peg, or screw, great care being taken that any alteration in the articular surface is overcome. The single fragment thus formed is now fixed firmly to the shaft. Passive movements should be commenced in about four to five days, being given with great care at first. Massage is commenced as soon as the wound is healed. Both should be continued until the movements at the joint are quite free. By this means all tendency to ankylosis is overcome.

In some cases of old fracture with limitation of movements and displacement of the lower fragment, a secondary operation may be undertaken, the bone being divided with a chisel or Gigli's saw, and the lower fragment fixed in a good position. Rarely, with much increased bone formation and ankylosis, excision of the elbow-joint may be required.

Of the External Condyle [9].—This fracture may be brought about by direct violence upon the outer surface of the arm, or by indirect violence applied to the hand when the arm is flexed to a right angle. In this case the radius is apparently driven upwards against the capitellum. It may be associated with a backward dislocation. The line of fracture is from above the condyle downwards and inwards to the middle or inner side of the capitellum. The joint is necessarily always opened (Fig 42). Most commonly the fragment is displaced upwards, but it may pass nearly wholly backwards.

Symptoms: Whether due to direct or indirect violence, there will always be considerable swelling, owing to the effusion into the joint. If due to direct violence, there will be more local bruising, and perhaps laceration of the soft tissues. The arm will be held in a position of semiflexion. Normally the axis of the forearm is deviated outwards from the line of the axis of the upper arm. The amount of this deviation is variable, but is generally alike on both sides. In cases of fracture of the external condyle, this deviation is increased on the affected side, the angle so formed, the carrying angle, being decreased. The normal relationship of the three bony points at the elbow will be disturbed. The external condyle may show abnormal mobility when gripped between the finger and thumb, these movements being accompanied by crepitus. The relationships of the external condyle and the head of the radius are not usually disturbed, the head of the radius accompanying the displaced fragment.

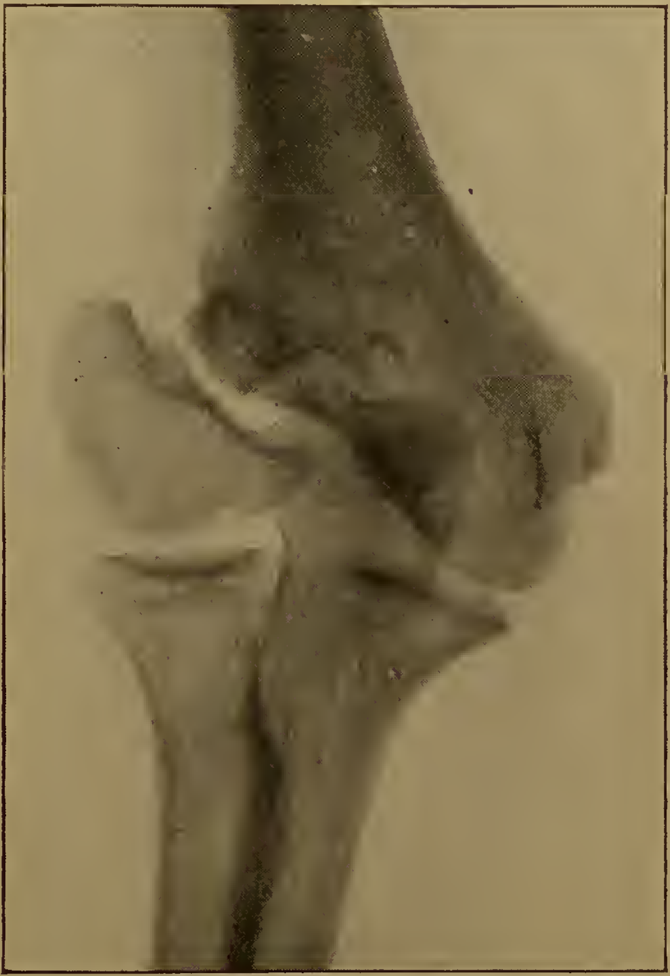

FIG. 42.—FRACTURE OF THE EXTERNAL CONDYLE OF THE HUMERUS. (Mr. Furnivall's Case.)

Pronation and supination may be decreased. Rarely such a fracture may occur before the epiphysis has joined.

A radiograph should be taken in all these cases.

Treatment.—If the displacement be mainly backwards, it may be possible to obtain good position by putting up the arm in a position of full flexion, as advised for other injuries in this neighbourhood. If upwards, an attempt should be made to draw the fragment downwards and fix it in position, with the arm on an internal angular splint, the results being judged by the appearance of a radiograph. Such methods often fail, and, since early passive movements and accurate apposition are essential to a good function, it is always preferable in these cases to fix the fragment by open operation. This should be undertaken three to five days after the accident, so as to allow the œdema to decrease, the part being treated with evaporating lead lotion in the meanwhile. A curved incision should be made over the external condyle, with its convexity forwards ; the flap being turned backwards, the fragment is now drawn well into position, and fixed to the shaft with an ivory peg or screw. The wound is sutured without drainage and dressed without a splint. Passive movement is commenced in three to four days, and massage as soon as the stitches are removed.

Of the Internal Condyle [8].—Fractures in this position are nearly always due to direct violence. Either the whole condyle may be separated in a manner similar to that seen with the external condyle, in which case the joint is always opened, or the tip of the epicondyle may be alone fractured, when the joint is not involved.

In either case the ulnar nerve may be injured, or later involved in callus. This is more common in the latter variety.

If the whole condyle be separated, the fragment is mainly displaced upwards, and to a less degree backwards. The epicondyle when separated is not displaced to a marked degree. It passes somewhat downwards and forwards.

Symptoms.—In either variety there will be local pain, swelling, and bruising. If the joint be involved the swelling will be greater, and will mark out the joint cavity. In this case the carrying angle will be increased, the axis of the fore-arm tending to be displaced inwards. The separated fragment may be moved freely to the accompaniment of pain and crepitus. The relationship of the bony points will be altered.

Treatment.—If the epicondyle be alone fractured, the displacement will be so slight that simple fixation of the arm on an external angular splint, with a bandage applied over cotton-wool, will usually be followed by good results. If the whole condyle be separated, attempts may be made, as with the external condyle, to obtain good results by placing the arm in a fully flexed position, or by the use of an external angular splint, the fragment being held in place by a bandage or adhesive strapping.

If this succeed, as shown by a radiograph, the splint should be kept in position for two weeks, passive movements and very gentle massage being then commenced. If this method fail, an open operation should be undertaken, a flap being turned backwards and inwards, and the fragment fixed in a good position by the use of a screw or peg. The after-treatment will be similar to that for a fracture of the external condyle.

If the ulnar nerve show an incomplete division, massage is commenced early, a splint being applied to prevent the paralyzed muscles from being stretched by overaction of the opposing ones. If there be complete division or later involvement in callus (see Complications), the nerve should be cut down upon by a vertical incision and its ends sutured, or the nerve dissected out of the callus, excess of which is removed, and wrapped in Cargile membrane. Splintage and massage are continued until recovery is complete.

Separation of the Lower Epiphysis.—Ossification of the lower end of the humerus occurs as follows.

A centre appears for the capitellum at the second year, and one for the internal condyle at the third year. In the eleventh and twelfth years the centres for the trochlear and external condyle appear respectively (Thompson).[1] The three centres for the trochlear capitellum and external condyle join to form an epiphysis in the thirteenth year, the epiphysis uniting with the shaft in the seventeenth year. The centre for the internal condyle forms a distinct epiphysis, separated from the main one by a bony downgrowth of the shaft. It joins the shaft in the sixteenth year (Fig. 36). Although a complete epiphysis is only present at the thirteenth year, separation of the cartilaginous portion may occur much before this, early cases perhaps only containing the one centre for the capitellum.

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[1] *Textbook of Anatomy*, Cunningham, 1902, p. 189.

The line of separation is variable. In young children it closely follows the epiphyseal line, but later a portion of the diaphysis is often separated also.

J. Hutchinson,[1] from a study of fifty-two cases, concludes that a clean separation is uncommon after the age of five or six years. In some cases the amount of diaphysis separated may be sufficient to include the internal condyle, but here the condition is practically a supracondylar fracture. More rarely the epiphysis of the internal epicondyle may be alone separated.

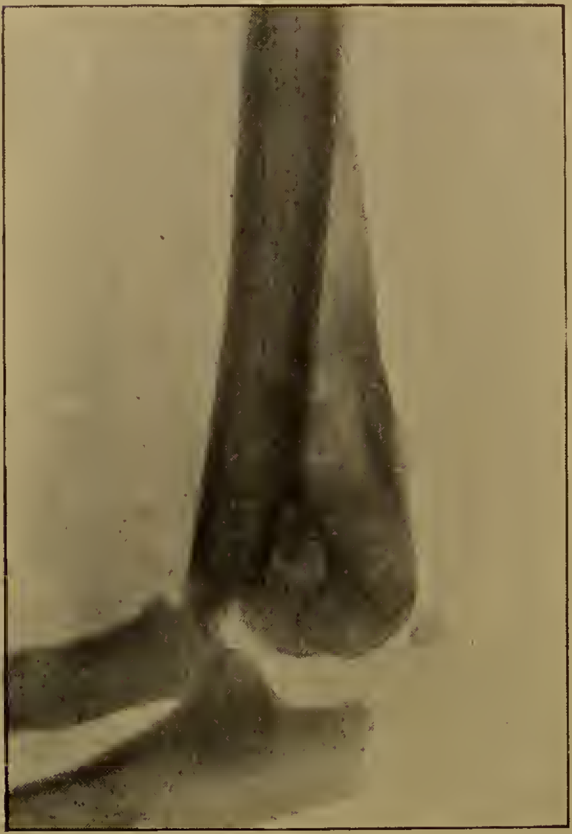

FIG. 43.—BACKWARD DISPLACEMENT OF LOWER EPIPHYSIS OF HUMERUS —NEW FORMATION OF BONE BENEATH THE STRIPPED-UP PERIOSTEUM. (Mr. Sherren's Case.)

The main epiphysis lies wholly within the joint cavity, so that its separation is of necessity accompanied by injury of the joint. The condition may arise from direct trauma to the elbow, or more commonly from falls upon the outstretched hand. Thus, in the majority of cases the epiphysis is displaced backwards (Fig. 43). If due to direct violence, a pure lateral or forward displacement may arise. The periosteum, being firmly attached to the epiphysis, is generally stripped off the shaft.

Symptoms.—The condition resembles very closely a backward dislocation at the elbow-joint or a supracondylar fracture. The elbow-joint itself is swollen and œdematous.

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[1] *Brit. Med. Journ.*, July 16, 1887.

In the common variety there is a well-marked prominence of the elbow in the backward direction, with a depression above it. The arm can be hyperextended, and on palpation the bony points are found to maintain their normal relationships. There is shortening of the upper arm, but not of the forearm. The lower end of the diaphysis is felt in front beneath the skin, and may even perforate it, leading to a compound separation. The deformity is readily reduced with the presence of soft crepitus, but rapidly returns. By these signs the condition is easily distinguished from a backward dislocation. Movements of the arm are much diminished, and the forearm is held midway between pronation and supination. After a short time the depression behind, above the epiphysis, is filled up, and thickening of the lower end of the diaphysis occurs owing to the rapid formation of new bone beneath the torn-up periosteum. Rarely the brachial artery may be compressed by the lower end of the diaphysis.

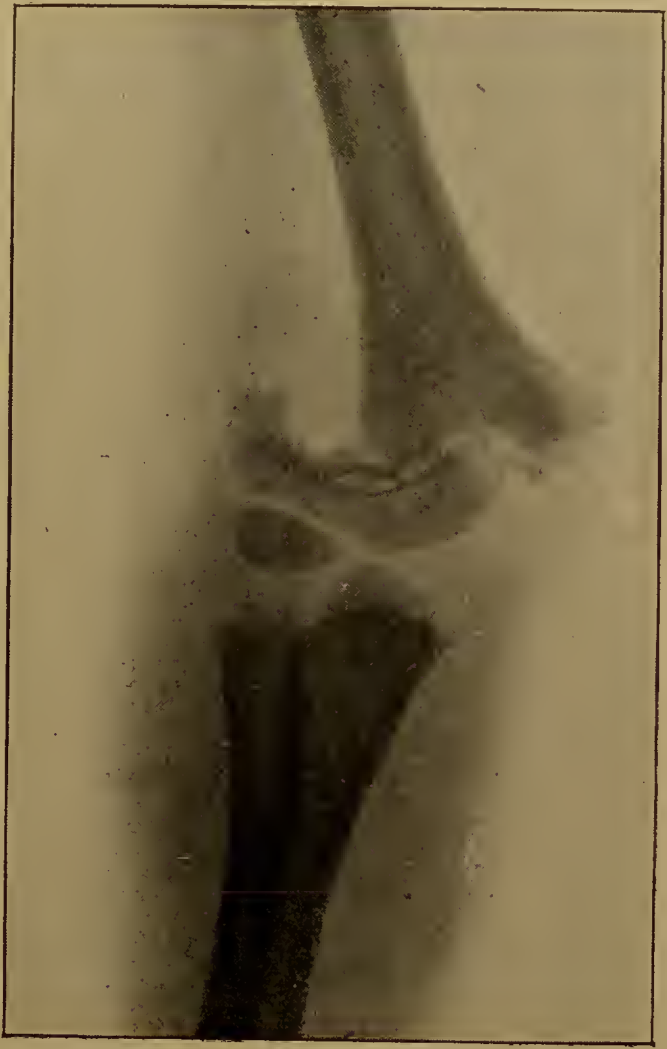

FIG. 44.—OUTWARD DISPLACEMENT OF LOWER EPIPHYSIS OF HUMERUS. (Mr. Furnivall's Case.)

If the displacement be lateral (Fig. 44), a prominence on the inner or outer side of the elbow will be apparent, with a depression above. The lower end of the diaphysis may be felt on the other side of the arm. Separation of the internal condyle is due to direct violence. There is local swelling and bruising, and the epiphysis may be felt to be freely movable. Injury to the ulnar nerve may occur at the time of the accident, or follow later from excessive formation of new bone.

Treatment.—In all cases the epiphysis must be fully reduced, or much limitation of movement will follow. An anæsthetic will generally be required, and, as in the case of supracondylar fractures, the displacement reduced by pulling upon the arm whilst it is in a flexed position. Here again the reduction is best maintained by putting up the arm in a fully flexed position in the same manner advocated for fractures of the lower third of the shaft, the amount of flexion being increased as the swelling decreases. The limb must be carefully and regularly examined for any evidence of undue pressure. Massage, at first very gentle, may be commenced in about two days, and gentle passive movements at the end of ten days, special attention being paid to obtaining full flexion, as this is the movement most likely to be limited. At the end of two weeks a simple sling is worn, being omitted after another week. Massage and passive movements may be required for some weeks more.

Lateral displacements may after reduction be treated in the same manner, or occasionally are better retained by internal or external angular splints. Methods aiming at reducing the deformity with a posterior angular splint will nearly always fail, and if reduction be impossible by the method of full flexion advised above, an open operation, with fixation of the epiphysis, will be the best treatment.

A vertical incision should be made over the elbow behind, or two lateral ones; by either means free access is gained to the joint and lower end of the humerus. The epiphysis is now manipulated into position, and fixed there with fine silver wire or a staple. In difficult cases this method undoubtedly gives the best results. The displacement backward, the rotation, and the tilting, can be almost wholly overcome, hence the mechanical limitation of movement and the excessive callus formation may be very largely prevented. The wound is sutured without drainage, a dressing, but no splint, applied, and the arm bandaged in a position of full flexion.

Passive movements may be commenced in about five or six days, and massage after the stitches have been removed.

In long-existent cases, where the deformity has not been fully overcome, there is often very marked limitation of movement, due to the following factors: Projection of and excessive formation of callus around the lower end of the diaphysis in front, which, coming into contact with the coronoid process, limits flexion; a mass of new bone formed behind beneath the periosteum; tilting and rotation of the epiphysis, which prevents the olecranon fitting into the olecranon fossa, and thus limits extension. In these cases operative treatment may be required. If fairly recent—*i.e.*, three to four weeks after the injury—it may be possible, by dividing the bone and removing callus, to return and fix the epiphysis in its normal position. Loss of growth in such cases will not be marked, as after the age of nine to ten years this does not amount normally to more than about ⅓ inch. In later cases it will often be best to make an incision on the outer side of the arm, and chisel off the projecting end of the diaphysis and any excess of callus, and thus remove the factor preventing flexion. In some severe and neglected cases ankylosis may be sufficiently great to call for excision of the joint.

Prognosis of Fracture of the Humerus.—Fractures of the anatomical neck, especially in elderly people, are very prone to be followed by pain and limitation of movement, especially abduction. This condition is partly due to excessive callus, and partly to traumatic osteo-arthritis; often fibrous union will alone result. In younger people similar results, with limitation of power in the affected arm, may persist for months, and weakness of the muscles, especially the deltoid, is very prone to occur, so that the patient may be unable to follow his occupation for months. With open operative treatment the results should be very much better, and a perfectly useful arm follow within about six to eight weeks, this being more likely to take place the earlier passive movements are commenced.

Fractures of the surgical neck are likely to be followed by the same pain and limitation of movements. If the lower fragment be not brought into accurate apposition with the upper, and the rotatory deformity overcome, there may be a resulting limitation of external rotation. The affected limb may for some months be painful when moved, and show wasting; and hard work, such as that undertaken by labourers, may be prevented for months, or even years. If good apposition be obtained and early massage given, the arm may, on the other hand, regain its normal functions after eight to ten weeks. Injuries to the brachial plexus or circumflex nerve may greatly add to the severity of the case and prolong the period of convalescence.

Separation of the upper epiphysis will lead to considerable difficulty in treatment, so that the results are often very poor; but there is no doubt that, if reduction be always brought about by manipulative or operative treatment, they are very much better. A certain amount of pain and limitation of movement in the shoulder-joint is very prone to continue even here, and added to these there is the possibility of limitation in the growth of the bone, which in younger patients may be very marked, and cause severe consequent deformity. The older the patient, the less likely this will be.

Fractures of the shaft should in the majority of cases be firmly united in about eight weeks, but complications leading to very prolonged disability are likely to occur in this position. The musculo-spiral nerve is not uncommonly injured at the time of the accident, or later from involvement in callus, and even if primary union of the divided nerve be undertaken, and great care manifested in the after-treatment, two years will probably elapse before the patient is able to return to his work; whilst if treatment of this complication be deferred to a later date, the convalescence will be even more prolonged. This is also the most common position for non-union to take place, in which case a very prolonged period, often one of many years, may elapse before any union occurs, in spite of most thorough treatment (see Complications).

Even if firm union take place, it is a matter of common experience to find that the patient is unable to use the arm fully for several months, although it is possible that many such cases are kept up by considerations of the compensation laws; yet there is no doubt that pain and weakness after an accident of such a nature are very persistent.

Fractures of the lower extremity are also very prone to be followed by a certain loss of function, which may even be permanent. The joint is extremely liable to be injured, and limitation in movements thus follow, either from excess of callus or from alterations in the shape or position of the lower fragment of the humerus. Interesting statistics on this type of injury are given by R. Warren.[1] He found that with fractures of the lower end of the humerus there were seventeen good results, and four only fair.

He says that "fractures here do surprisingly well in spite of initial troubles, such as excess of callus, great stiffness, and some deformity. Callus melts away after persisting for months . . . and in very few cases does one find a great mass of it a year or more afterwards." These are, however, results with continued massage and passive movements, and there is no doubt that with such the prognosis is greatly improved. As regards separation of the lower epiphysis, he had twenty-eight cases: in twenty the results were good, half of these being anatomically perfect. As showing the value of early massage and passive movements, he says: "When the cases were splinted for from one to three weeks, the after-treatment averaged seven weeks; but in cases splinted for four to six weeks it averaged thirteen weeks."

Of his series of fracture of the surgical and anatomical necks, nine showed good results, six only fair, one bad, and one not traced. The bad result was due to injury of the brachial plexus.

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[1] *Lancet*, July 24, 1909, p. 221.

CHAPTER X

FRACTURES OF THE ULNA AND RADIUS

THE ULNA.

FRACTURES of this bone are not uncommon. Flower and Hulke and Morris[1] give the frequency as 83 in 1,858 cases of fracture. It may be fractured alone, in association with fractures of the radius, or in combination with dislocation at the elbow or superior radio-ulnar joints. The following varieties may be recognized (Fig. 45):

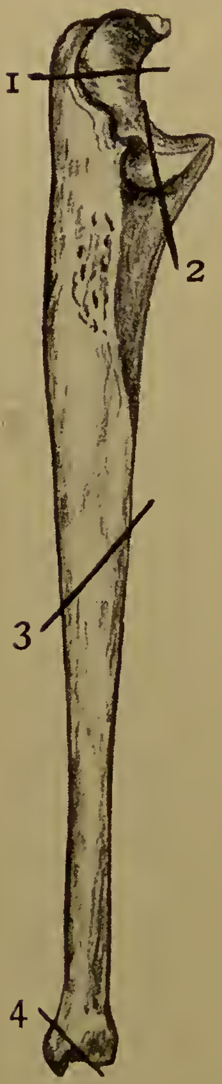

FIG. 45.—ULNA, SHOWING SITES OF FRACTURE.

Olecranon [1].—Fractures of the olecranon process are nearly always due to direct violence from falls upon the tip of the elbow, but rarely they may be caused by excessive muscular contraction of the triceps. For this reason they are much more common in men than in women, and occur most frequently during adult age, so that they are extremely rare before the age of fifteen. The site of the fracture is variable. Most commonly it takes place at the narrowest part of the bone—*i.e.*, opposite the centre of the joint—but in some cases a mere flake of bone is separated. Most frequently the separation is complete (Fig. 46).

After the bone is fractured by direct violence, contraction of the triceps causes rupture of the aponeurotic continuation of that muscle and of the periosteum. The fragment is then drawn up the posterior surface of the arm by the contraction of the triceps, so that it may be separated from the rest of the bone by an interval of an inch or more, this separation being increased with flexion of the elbow. In such cases the upper fragment is often somewhat tilted, and the ruptured aponeurosis curls in over the fractured ends of both fragments, for which reason accurate reposition is almost impossible. In this variety the fracture always involves the joint. On examination there may be bruising, or even laceration, of the soft tissues from the direct violence, this laceration seldom being sufficient to make the injury compound. The elbow-joint will be much swollen, and later may be greatly discoloured from absorption of the effused blood. Movements of the elbow-joint will be weak and painful, the power of extension being almost entirely lost. On following up the subcutaneous crest of the ulna, the surgeon will be able to feel a marked depression at the site of the fracture, the width of this increasing when the elbow is flexed. Crepitus will only be obtained if the two fragments can be brought into apposition.

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[1] *A System of Surgery*, Holmes and Hulke, 1883, pp. 946 and 995.

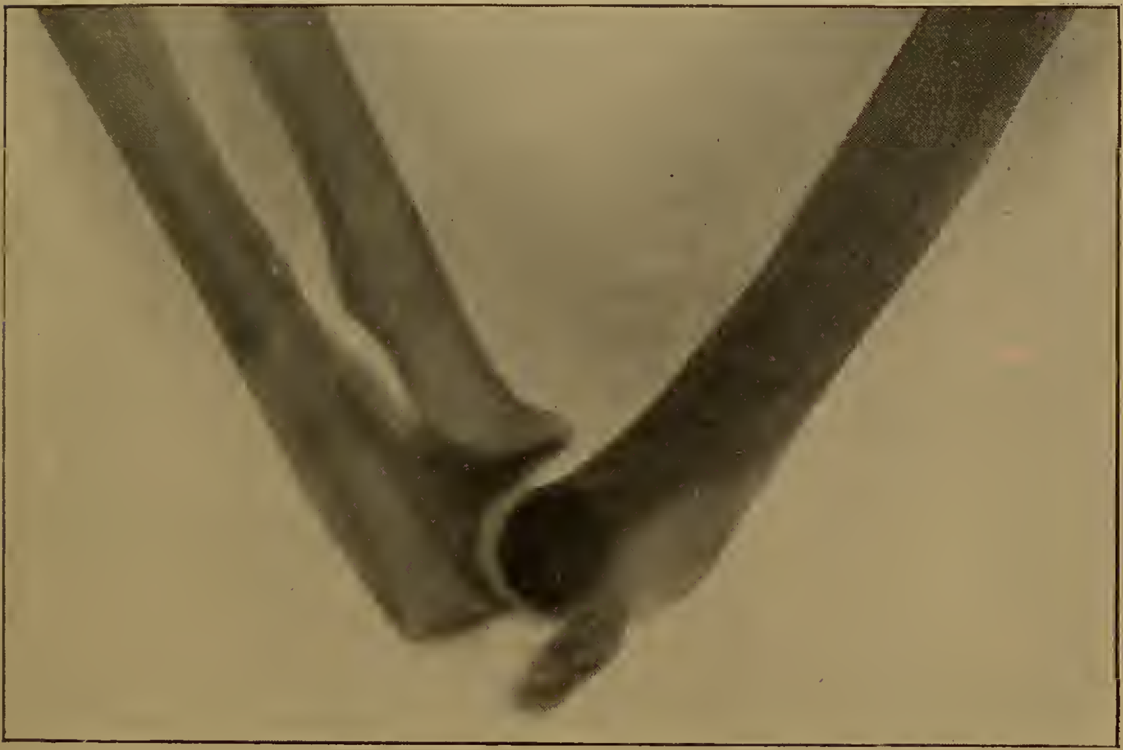

FIG. 46.—FRACTURE OF OLECRANON PROCESS OF ULNA.
(Mr. Furnivall's Case.)

In a smaller number of cases the aponeurosis and periosteum are not completely torn, when separation will be incomplete, and the condition therefore much less evident. A slight irregularity may be felt along the crest of the bone at the site of the fracture. Care must be taken not to mistake the small masses of fibrin deposited in the olecranon bursa, after direct violence, for the irregularity of a fracture. This mistake, which is not uncommon, can be easily rectified by a radiograph. If the bone be really fractured, there will also generally be some effusion into the joint. Movements of flexion and extension will be painful, and therefore weak, but can be accomplished. If these be persisted in, there is danger of the separation becoming complete. Crepitus may be obtained, but often the diagnosis is only made absolute by a radiograph.

Treatment.—Owing to the wide separation of the fragments, the tilting of the upper portion, and the interposition of portions of aponeurosis between the fragments, accurate apposition and consequent bony union is very exceptional, and for this reason, unless there be no separation or some grave counter-indication, an open operation should always be undertaken. It is never justifiable to send away an adult man of the labouring classes with a straight splint, as is so often done. By such means fibrous union is alone obtained, and he is unable to do any but the lightest work with the affected arm.

Several days or a week are allowed to elapse subsequent to the injury, so that the greater portion of the effused fluid may be absorbed. An incision is now made to lay bare the fracture. This is preferably made as advised by Sir Watson Cheyne,[1] in a curved form, a flap being turned downwards. The upper part of the incision should lie $\frac{1}{2}$ to 1 inch above the seat of fracture. When the flap is turned down the fracture is laid bare. The edges of aponeurosis which are turned in over the fractured surfaces are elevated or cut off. All blood-clot is removed from the cut surfaces and from the joint with a pledget of sterilized gauze on a holder, or it may be washed out with saline. The fragments are now carefully drilled, the upper one being gripped if necessary in a pair of lion forceps. Care must be taken in drilling these holes that they are opposite one another on the fractured surfaces, otherwise accurate apposition will not be obtained. The joint cavity may be protected with a strip of sterile gauze before doing this. The holes must not encroach on the joint surface. They are preferably drilled always from the surgeon's right hand—*i.e.*, towards the fractured surface in the case of the right-hand fragment, and away from it in the case of the left-hand fragment, the aponeurosis being divided where the drill enters the right and leaves the left-hand fragment.

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[1] *Manual of Surgical Treatment*, 1905, part iii., p. 85.

Two cannulæ are inserted so that their points emerge on the fractured surfaces, and the wire passed down the right-hand one towards its point, and up the left-hand one away from its point (Fig. 47). The cannulæ are then removed, the fragments being brought into apposition with the arm fully extended. The ends of the wire are firmly twisted together, and excepting for about ¼ inch cut off, the twisted remaining portion being hammered down into the bone. The skin is sutured without drainage, and a dressing, but no splint, applied. Passive movements are commenced at the end of a week, and gentle massage after the stitches are removed—*i.e.*, on the tenth day. Active movements are allowed at the end of two weeks, and light work at the end of three. Hard work is not allowed until the end of six weeks. In old cases with much separation, a method similar to that advised by Lord Lister in the case of the patella is much preferable to lengthening the triceps, and should be tried.

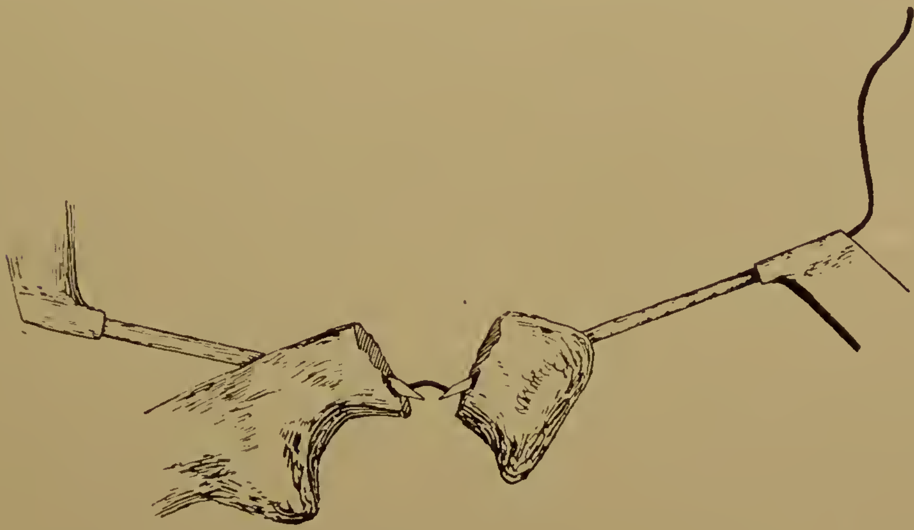

FIG. 47.—METHOD OF INSERTING THE WIRES IN A FRACTURED OLECRANON.

If there be no separation, it is only necessary to keep the arm extended and to prevent all movements, so that rupture of the aponeurosis does not take place. For this purpose a long anterior splint should be applied, the arm being fixed in a position of full extension. Massage and passive movements are commenced at the end of four to five days, the splint being reapplied until the end of two weeks. By this means adhesions in the joint are prevented. At the end of two weeks light active movements are allowed in addition to the massage and passive movement, which is continued together with the use of a sling for two more weeks.

If there be much separation, but some grave counterindication to operation, such as advanced old age, kidney disease, or diabetes, a somewhat similar method is adopted. A long anterior splint is applied by straps, and massage commenced at once, attempts being made between-whiles to draw down the upper fragment by an oblique strap passing above it. The splint should be maintained in position for six weeks, but bony union is very unlikely even if good apposition be obtained, owing to the interposition of the aponeurosis. Slight passive movements may be commenced at the end of three to four weeks.

As already mentioned, Lucas Championnière[1] claims very good results from massage and passive movements alone in all cases, and advises against wiring; but bony union here is unlikely, for even if approximation be brought about the aponeurosis will remain turned in between the fractured surfaces.

Coronoid Process [2].—Fractures of this process are extremely rare, and are said to occur almost wholly in association with backward dislocation of the forearm. In such cases the dislocation is very readily reduced, but tends to recur almost at once. The separated fragment is drawn upwards by contraction of the brachialis anticus. The condition will only be made definite by a radiograph.

Treatment.—Approximation of the fragments is extremely difficult, even by open operation. Fortunately, but little disability seems to follow failure of bony union, the action of the brachialis anticus probably being compensated by hypertrophy of the biceps. The backward dislocation being reduced, the arm is put up in full flexion. By this means the tendency to recurrence of the dislocation is overcome, and the fragments are placed in a position most favourable to bring about union. The arm is supported in this position by the method advised for fractures of the lower end of the humerus. Massage to the biceps and brachialis anticus should be commenced in a few days, to overcome spasm of these muscles, and to the joint to aid in absorption. At the end of two to three weeks passive movements may be commenced, active movements being allowed at the end of four weeks. If there be much separation, and much disability follow, an open operation is advisable. This should not be undertaken for separation alone, as the upper part of the ulna is so deeply buried in muscles that attempts at fixation of the two fragments are very prone to fail. An incision is best made both on the inner and outer side of the arm level with the joint, and carried up on either side of the biceps, care being taken to avoid the median and musculo-spiral nerves. The fragment, being found, is pulled down, and attempts may be made to fix it in position, but these are very likely to be unsuccessful. If so, the fragment should be removed. The wounds are then sutured and dressed, passive movements being commenced in a few days, and massage when the stitches are removed.

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[1] *Journ. de Méd. et de Chir. Prat.*, July 10, 1908, p. 481.

Separation of the Upper Epiphysis.—Separation of the upper epiphysis of the ulna is extremely rare. The epiphysis forms a mere plate of bone at the end of the olecranon process. A centre appears for it at the age of ten years, and unites with the shaft at the age of sixteen (Fig. 50). Should it be separated, the condition will resemble a fracture of the olecranon high up. There will be little or no displacement, as the attachment of the triceps extends well beyond the area of the epiphysis. In such cases palliative treatment will alone be required. More rarely the tendon of the triceps will also be torn, in which case the epiphysis will be more widely separated and an open operation may be required, not so much to prevent lack of growth—for the amount of bone formed from this epiphysis is very slight—as to overcome the disability, which will be similar to that occurring with a fractured olecranon.

The Shaft [3].—The shaft may be fractured in any part of its length, the cause being more commonly direct violence. The accident is not a common one, it being more usual for both bones to be fractured. The deformity will usually be but slight, overriding of the two ends being prevented by the radius, which acts as a splint. If fractured in the upper

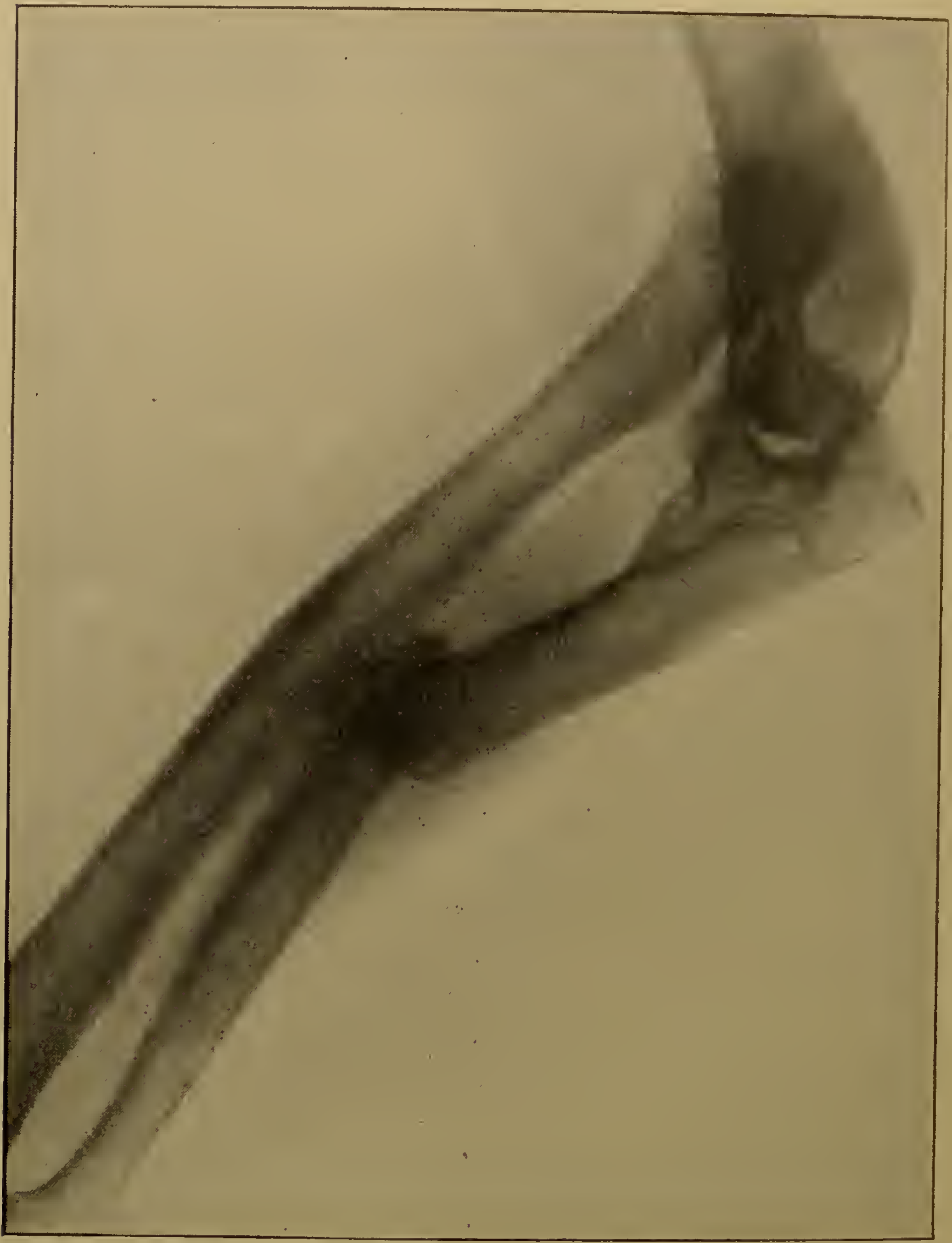

FIG. 48.—FRACTURE OF SHAFT OF ULNA, WITH DISLOCATION OF HEAD OF RADIUS FORWARDS. (Mr. Openshaw's Case.)

This case was of ten years' standing, but was successfully treated by open operation.

part, the upper fragment may be drawn forward and flexed on the humerus by the action of the brachialis anticus. If near the wrist, the lower fragment is often drawn in towards the radius by the action of the pronator quadratus. Often, however, a fracture in this position is associated with but very little displacement (Fig. 49). A not uncommon condition is a combination of a fracture of the shaft with a dislocation forwards of the head of the radius, the one condition being dependent upon the other. In this case the ulna is fractured rather above the middle of the shaft (Fig. 48).

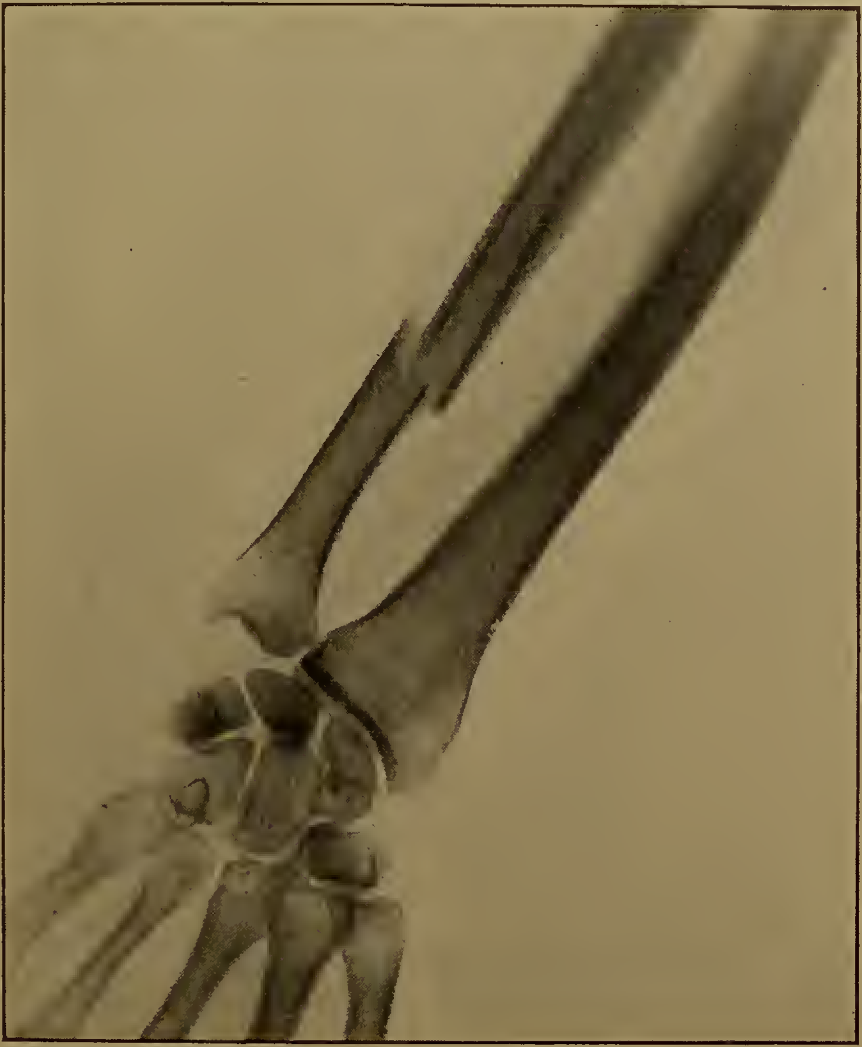

FIG. 49.—FRACTURE OF SHAFT OF ULNA LOW DOWN.
(Mr. Lett's Case.)

Symptoms.—There will be local swelling and bruising of the part, but the axis of the forearm will be but little altered. Movements, especially those of pronation and supination, will be painful and associated with crepitus. Since the posterior border of the ulna is subcutaneous in nearly its whole length, any inequality of this surface is manifest, as is also any overlapping of the two fragments. When the fracture is oblique, with much overlapping, one of the fragments may perforate the skin. If the head of the radius be dislocated forwards there will be a well-defined angle just above the middle of the forearm, and the head of the radius will, on movements of rotation, be felt in an abnormal position.

Treatment.—In simple cases of fracture of the shaft alone, reposition is easily brought about by gentle extension, and will not, except in the case of muscular men, usually require an anæsthetic. The fragments having been brought into good position, the arm should be put up midway between pronation and supination, as in this position the radius and ulna are farthest apart, and thus cross-union is less likely to occur. For this purpose simple antero-posterior splints may be used, but they must project beyond the elbow, or rotation of the arm with the splints will easily take place. This is even better prevented if the internal straight splint be replaced by an angular one reaching halfway up the arm. Both splints should only reach halfway along the palm, so that movements of the fingers are quite free. They should be fixed by straps, so that they may easily be removed, and massage commenced on the third or fourth day, the arm being supported during the massage, and the splints replaced after it. At the end of three weeks the splints should be dispensed with, and a sling worn for another week or two, massage and passive movements being continued until all stiffness has gone.

If the head of the radius be also dislocated forwards, attempts must be made to overcome both deformities under an anæsthetic. Firm extension is applied to the forearm while it is flexed to a right angle, and the head of the radius replaced by pressure over it. As the radius goes back into position the angular deformity of the ulna will be overcome. Sometimes in young children these attempts are followed by separation of the epiphysis of the head of the radius. In these cases, or where attempts at reposition fail, an incision about 2 inches long should be made over the head of the radius, which is replaced with the aid of extension on the forearm. If possible, the epiphysis should then be fixed in position with a small peg or wire. If this fail, it may be removed, but little disability following this treatment. The arm is put up as before, and passive movements should be commenced on the third day, special attention being given to pronation and supination.

In old cases where the deformity has been unreduced, it will be necessary not only to cut down upon and remove a portion of the head of the radius, but an incision must also be made over the ulna, this divided at the site of fracture, excessive callus removed, and when the deformity is reduced the ends fixed with wires or plates. Passive movements of pronation and supination may then be commenced early, and must be persevered with, lest ankylosis at the superior radio-ulnar joint take place.

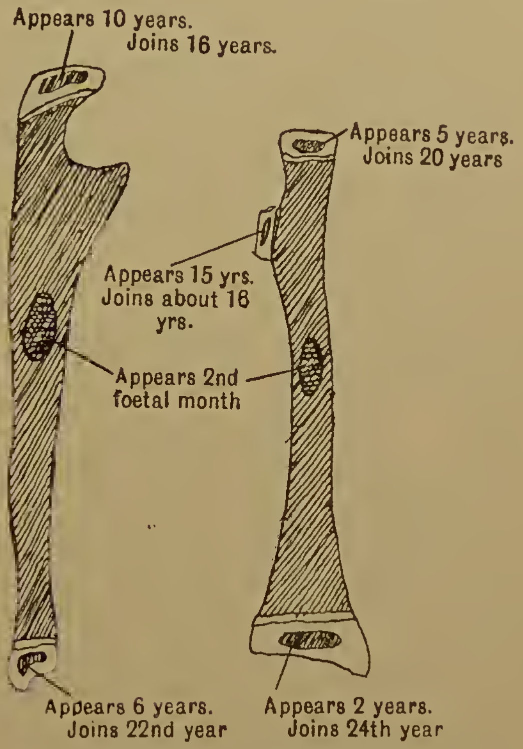

Fig. 50.—Ossification of the Ulna and Radius.

The Styloid Process [4].—Although commonly found in association with fractures of the lower end of the radius, this fracture alone is not often seen. It may, however, occur from direct violence. There are then signs of local trauma with increased pain, and crepitus on radially abducting the hand, the separated fragment being then drawn down by the internal lateral ligament.

The hand should be fixed in a position of ulnar adduction by a poroplastic splint, which is kept in position for two weeks. Union by fibrous tissue usually results. If the patient complain of pain, weakness, or disability, after this treatment, an incision may be made and the process fixed in position by a small peg.

Separation of the Lower Epiphysis.—A centre appears for the lower epiphysis of the ulna at about the sixth year, and joins with the shaft at a period varying from the twentieth to the twenty-third year. It includes the styloid process, the head of the bone, and the articular surface for the radius (Fig. 50). It is very rarely separated, Hutchinson[1] giving the following reasons: Trauma is mostly directed upwards through the radius; the thinnest part of the ulna is about 1½ inches above the joint, and the epiphyseal line is markedly convex downwards. To these may be added the fact that it is firmly attached to the lower end of the radius.

Separation would lead to a marked prominence of the lower end of the ulna, generally behind. Movements of pronation and supination will be limited and painful, and soft crepitus will be obtained. The displacement should be reduced, under an anæsthetic if necessary, and maintained in position for a week or ten days on antero-posterior splints.

THE RADIUS.

Of all bones in the body, with the exception of the clavicle, the radius is the most commonly fractured. This is chiefly due to the fact that in elderly and middle-aged people a fracture of the lower end of this bone is extremely common, and very easily brought about.

Flower and Hulke and Morris[2] give the frequency of fracture of this bone as 320 out of 1,858 cases.

Of the Head and Neck [1].—Fractures in this position may be caused by direct or indirect violence; the former is more common in adults, the violence taking the form of a blow upon the head of the bone, which is uncovered by muscles. In such cases the head may be comminuted, and loose portions detached into the joint—a condition very likely to be followed by ankylosis—or the bone may fracture transversely across the neck just below the head. Indirect violence, generally falls upon the outstretched hand, is a more common cause in younger people, and in them fracture may be replaced by separation of the upper epiphysis, or be associated with dislocation, most often of the head of the radius forwards.

Symptoms.—Fractures of the head (Fig. 52) will be associated with pain and swelling over the upper end of the radius, movements of pronation and supination increasing the pain and being accompanied by crepitus. Since the orbicular ligament is uninjured, there will be no displacement of the shaft. If the fracture be comminuted, loose fragments may greatly limit movement, whilst later excessive bone formation will be very likely to cause ankylosis of this joint.

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[1] *Brit. Med. Journ.*, July 16, 1887.

[2] *A System of Surgery*, Holmes and Hulke, 1883, pp. 946 and 995.

If the neck be fractured, the amount of local trauma will vary according to whether the fracture was caused by direct or indirect violence. There will be pain on moving the arm, with crepitus, which will be soft in nature if the epiphysis be separated. In this case the epiphysis is usually displaced forward, probably from the fact that the injury has led to a partial anterior dislocation, the shaft being separated from the epiphysis, then passing back into its normal position, and leaving the epiphysis still displaced. When the neck is fractured, the upper fragment usually maintains its position, owing to the presence of the orbicular ligament, and the lower fragment is drawn somewhat forward by the biceps, forming a prominence on the front of the arm which is increased by attempts at flexion. Rotatory movements of the hand are not accompanied by movements of the head as felt subcutaneously. The hand is held pronated, and there is a loss of the power of supination, the biceps acting merely as a flexor, owing to the absence of the fulcrum. All these injuries are made clear by a radiograph. Ewing[1] states that such fractures are shown by this method to be common, and are generally due to falls on the outstretched hand.

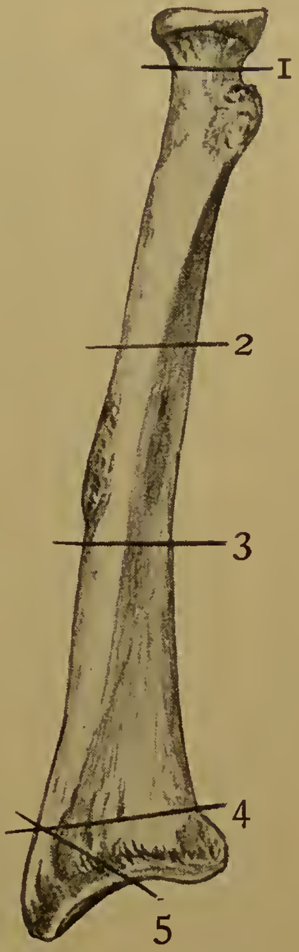

Fig. 51.—Radius, showing Sites of Fracture.

Treatment.—Fractures of the head are best treated by open operation. If early passive movements are commenced, non-union will result, and the fragment simply act as a foreign body in the joint, whilst if the limb is fixed ankylosis of the joint will probably occur.

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[1] *Amer. Journ. Orthopæd. Surg.*, April, 1908.

An incision should be made directly over the head of the bone parallel to the long axis of the radius. The joint having been opened, the fragment should, if possible, be accurately fixed to the shaft with a small peg or wire. If this fail it should be removed, and the remaining portion of the neck rounded off.

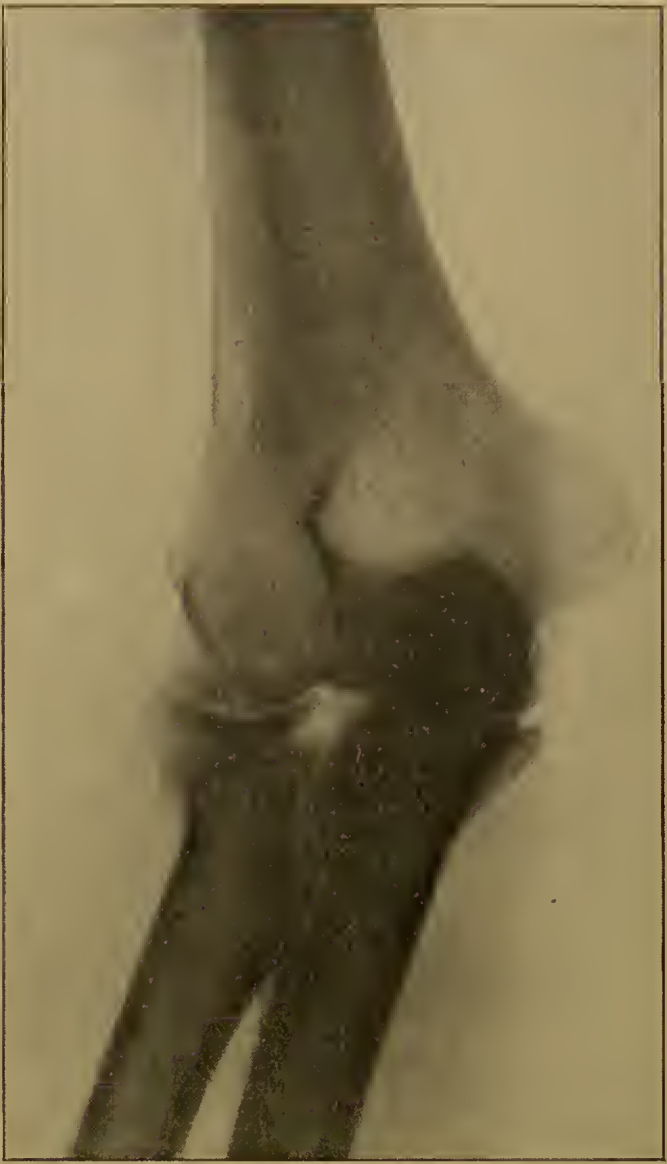

FIG. 52.—FRACTURE OF HEAD OF RADIUS. (Mr. Rigby's Case.)

The wound is closed without drainage, and passive movements commenced within one or two days. If operation be refused, the arm may be put up in antero-posterior splints, midway between pronation and supination, for three weeks, after which passive movements are commenced. Such treatment is, however, very likely to be followed by marked limitation of movement at the joint.

If the neck be fractured, the arm should be put up in a position of flexion, as by this means the biceps is relaxed and forward displacement of the lower fragment overcome. It may be maintained in this position by a posterior angular splint, or by strapping the wrist to the upper arm.

Massage should be commenced in a few days, and passive movements at the elbow in two and a half weeks. Pronation and supination should not be allowed for another week, the arm being then carried in a sling.

Of the Shaft.—Fractures of this portion are more commonly due to falls upon the hand, for this bone mainly transmits upwards any force applied to the hand. They are less commonly due to direct violence, for the bone is well covered by muscles in the greater part of its length. Two distinct types of fracture occur—those above and those below the insertion of the pronator radii teres. In young children either variety may be greenstick in nature.

Above the Pronator Radii Teres [2].—The insertion of this muscle is often given as too high up, the result being that many fractures, which are really above the insertion, are regarded and treated as those below, the effect being often disastrous as regards the after-efficiency of the limb. If the fracture be above the insertion, the upper fragment will be fully supinated, as the two main supinators of the arm—viz., the biceps and the supinator brevis—are attached to it (Fig. 53). The action of the biceps will also cause it to be somewhat flexed. The lower fragment will be pronated, but, being easily controlled by movements of the hand, its position is of but little importance. The pronator quadratus will also tend to approximate it to the ulna. For practical purposes any fracture situated above the mid-point

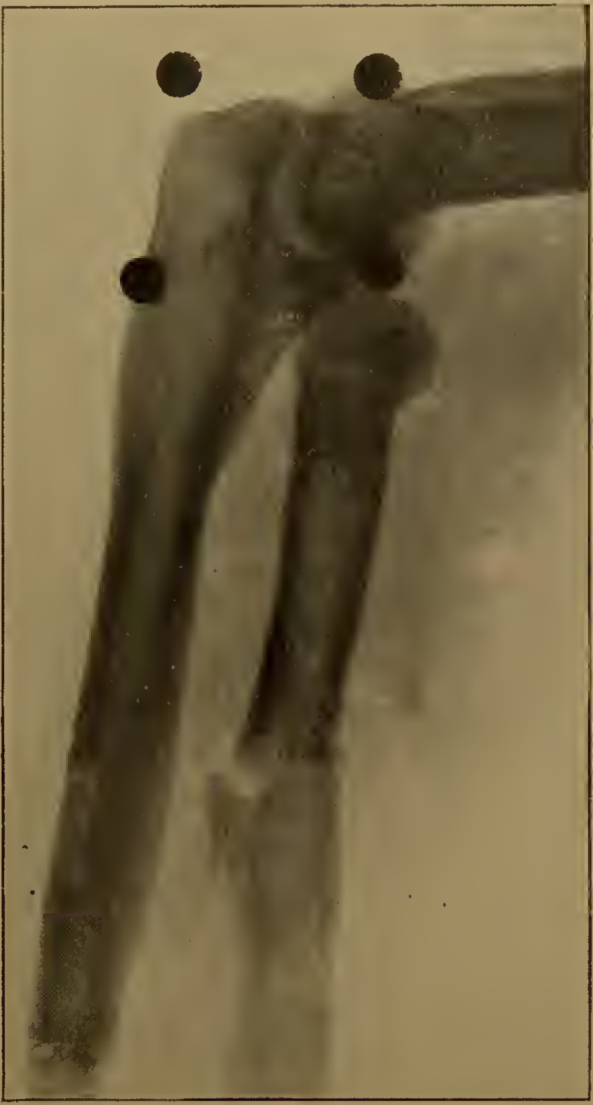

FIG. 53.—FRACTURE OF RADIUS ABOVE THE PRONATOR RADII TERES.

The bicipital tubercle on the upper fragment is invisible owing to the supination. Compare with Fig. 46, which is taken in the same plane. There a fracture of the olecranon is alone present, and hence the supination is absent.

of the radius may be regarded as being above the insertion of the pronator radii teres. But, as shown by Martin,[1] the important fact as to whether the fracture be above or below this insertion can be shown more accurately as follows. The forearm is placed in a position midway between pronation and supination, and a radiograph taken with the plate on the palmar surface. In the normal arm, or with a fracture below the insertion, the bicipital tubercle is easily seen. If, on the other hand, the fracture be above the insertion, the upper fragment is so far supinated that the tubercle does not project backwards, and is no longer visible on the plate (Figs. 53 and 46).

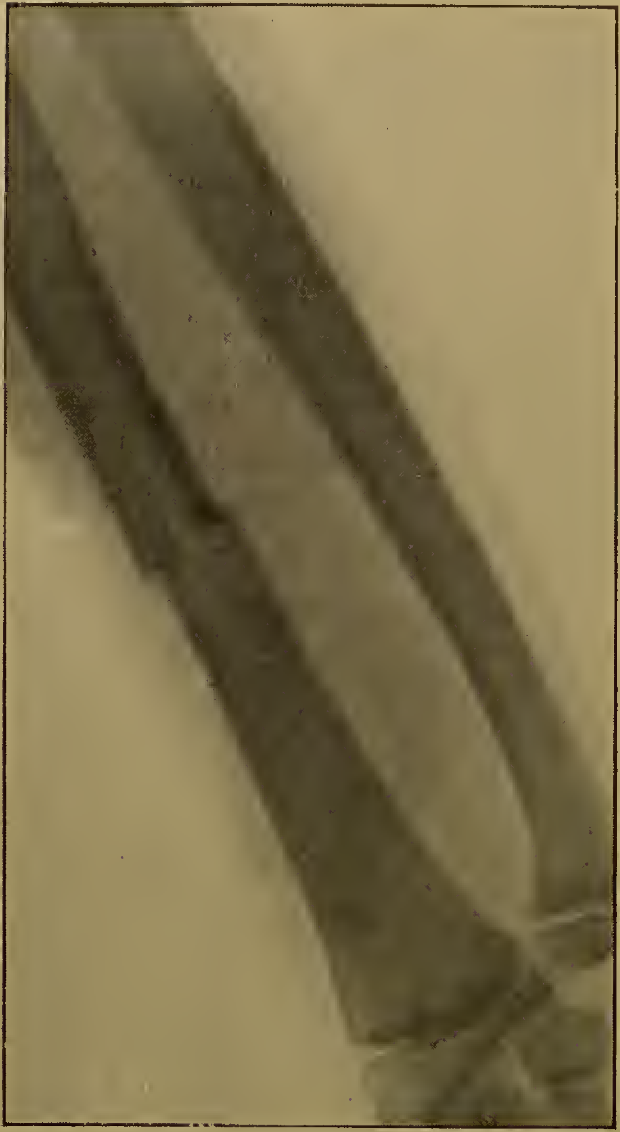

FIG. 54.—FRACTURE OF THE SHAFT OF THE RADIUS BELOW THE INSERTION OF THE PRONATOR RADII TERES. (Mr. Howard's Case.)

Below the Pronator Radii Teres [3].—In this case the upper fragment will have a powerful pronator, the pronator radii teres, attached to it, which will be sufficient to overcome the action of the supinators, the bone then lying in a position midway between the two. It will also be somewhat flexed by the action of the biceps. The lower fragment will tend to be approximated to the ulna by the action of the pronator quadratus (Fig. 54).

Symptoms.—In either variety there will be loss of power in the arm, especially of pronation and supination. Attempts at these movements are associated with severe pain. On rotating the hand there will be crepitus with pain, whilst the head of the bone will remain immobile in its socket. Alterations in the shape of the arm are not marked, the position of the limb being maintained by the ulna.

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[1] *Trans. Roy. Med. Soc.*, January, 1909, Elect.-Therap. Sect., p. 35.

Treatment.—If the fracture be situated above the insertion of the pronator radii teres, it is essential that the forearm be put up in a position of full supination. Neglect of this precaution will mean that, when union has occurred, the upper portion is fully supinated, while the lower is midway between the two positions, and can thus be supinated no farther. There is therefore loss of nearly one half of the normal degree of rotation, and great disability follows. Fixation of the forearm in a position of supination is, however, by no means easy, and causes considerable discomfort to the patient. An anæsthetic is often necessary to obtain it, extension of the two fragments being applied at the same time as external rotation. When once the fragments are in good position, fixation will best be obtained by a posterior moulded angular splint. An angle of about 90° at the elbow-joint will generally be found most comfortable for the patient, but at times a smaller angle will be preferable. If a splint be made with a movable angle at this joint, gentle passive movements of flexion and extension may be commenced here after a few days, without altering the position of the fragments. Similar movements should be commenced at the wrist from the first. If the splint be fixed with straps, gentle massage to the muscles of the forearm may also be given after a day or two. The splint should be maintained in position for three to four weeks, the arm being supported in a sling. After this time gentle rotatory movements are commenced, the splint being left off, but the sling worn for a further two weeks.

If the fracture be below the insertion of the pronator radii teres, the conditions will be different. Here the upper fragment, which cannot be controlled, will be in a position midway between pronation and supination, and the lower fragment must be brought into line with it. In this position also the radius and ulna are farthest apart, and thus there is less likelihood of cross-union; the position is also more comfortable for the patient. An internal angular wooden splint is applied; below it should reach just to the wrist, so as not to impede movements of the fingers and hand. It should be fixed in position by three straps over cotton-wool—two on the forearm and one on the arm—the arm and splint being then bandaged. A splint on the extensor surface of the forearm may be added if necessary. It is often advised that two splints be used, with a narrow longitudinal pad between the bones to push them apart and prevent cross-union. This is, however, useless, as sufficient pressure cannot be applied to the pad to press the bones apart without causing injury to the soft tissues. By using one splint and straps, massage may be applied from the very first, whereby muscular spasm is overcome, and no difficulty will as a rule be found in obtaining apposition. Should this method fail, as shown by radiography, an open operation with mechanical fixation of the ends should be undertaken. In long-existing cases where malunion has occurred, especially with cases of fracture above the insertion of the pronator radii teres, an incision should be made over the line of fracture, the fragments separated with a chisel or Gigli's saw, excess of callus removed, and the fragments fixed with wires or plates in a corrected position. The wound is closed without drainage. Massage and passive movements of the hand and elbow must be commenced within a day or two of the operation. Similar lines of treatment will be carried out where cross-union has taken place, but here, if the line of the radius be good, attempts will be made to sever the cross-union without dividing the bone itself. Usually, however, the position is so bad that separation of both fragments, with subsequent fixation, is necessary. After-treatment will be similar to that of the above variety.

If the fracture be greenstick in nature, an anæsthetic should be given, all deformity overcome, and antero-posterior splints applied for three weeks, early massage and passive movements being given.

Of the Lower Extremity.—The lower extremity of the radius is the commonest site of fracture, the most usual condition being that known as **Colles's Fracture** [4]. Here the lower end of the radius gives way transversely from side to side, about a half to one inch above the wrist-joint, the line of fracture being obliquely upwards and backwards. It is seen most frequently in women over the age of forty, and is produced in them by falls upon the outstretched hand, the elbow being flexed and the hand somewhat adducted radially and extended. In younger patients such an accident commonly gives rise either to no fracture or to a lesion around the elbow or shoulder joint. In these more elderly patients, however, the radius shows considerable rarefaction, and this type of fracture becomes extremely common, being often produced by slight trauma. The displacement is very constant and made up of several factors. The lower end is driven directly backwards (Fig. 55), so that a prominence is formed over the lower end of the radius on the extensor surface. It is driven upwards, so that the upper fragment is often found impacted into the lower. It is rotated backwards from the fall on the palm, so that when the arm hangs by the side the articular surface, instead of looking directly downwards, looks downwards and outwards—*i.e.*, towards the extensor surface. The force being mainly applied to the thenar side of the hand, the lower fragment is rotated towards the radial side, so that the hand is radially adducted (Fig. 56). This radial adduction is always a marked feature, and is often associated with rupture of the internal lateral ligament of the wrist-joint or separation of the styloid process of the ulna (Fig. 57). Not only is the lower fragment rotated round to the radial side, but it is displaced as a whole in the same

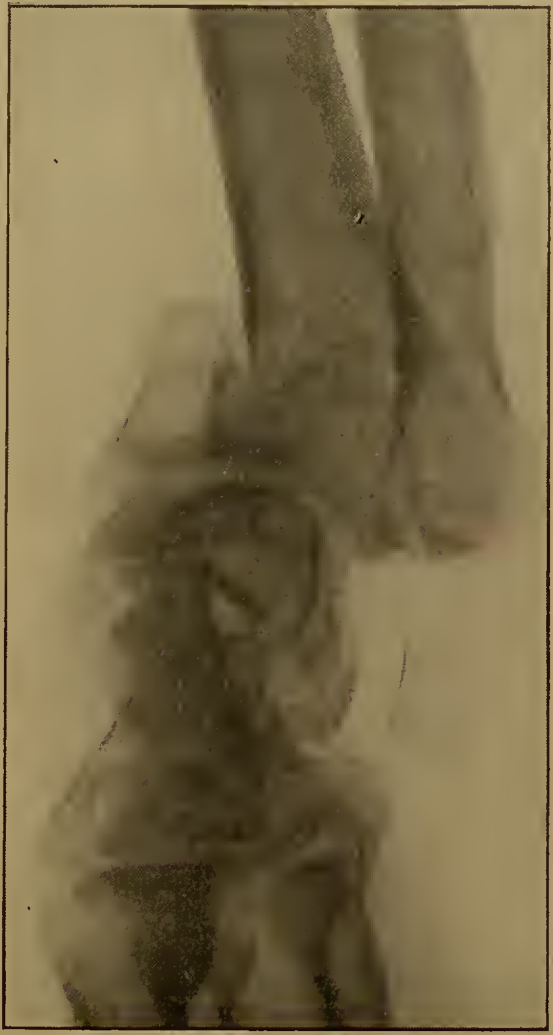

FIG. 55.—COLLES'S FRACTURE, SHOWING BACKWARD DISPLACEMENT OF THE LOWER FRAGMENT. (Mr. Furnivall's Case.)

direction. Very rarely the lower fragment may be displaced forwards instead of backwards (Fig. 58), and at times the triangular fibro-cartilage is torn, leading to separation of the radius and ulna.

Symptoms.—The patient, usually a woman past middle age, will present herself for an injury to the wrist, with the affected arm held in a characteristic attitude. The wrist is supported by the uninjured hand, the hand is extended at the wrist, this extension commencing somewhat above the joint, owing to the backward displacement of the lower fragment. At the same time the fingers are slightly flexed, the position of the hand and fingers resembling the curve of the shoulder and prongs of a fork, the condition hence being commonly known as the "dinner fork deformity." The backward displacement of the lower fragment causes a prominence over the lower end of the radius on the extensor surface, whilst a second promi-

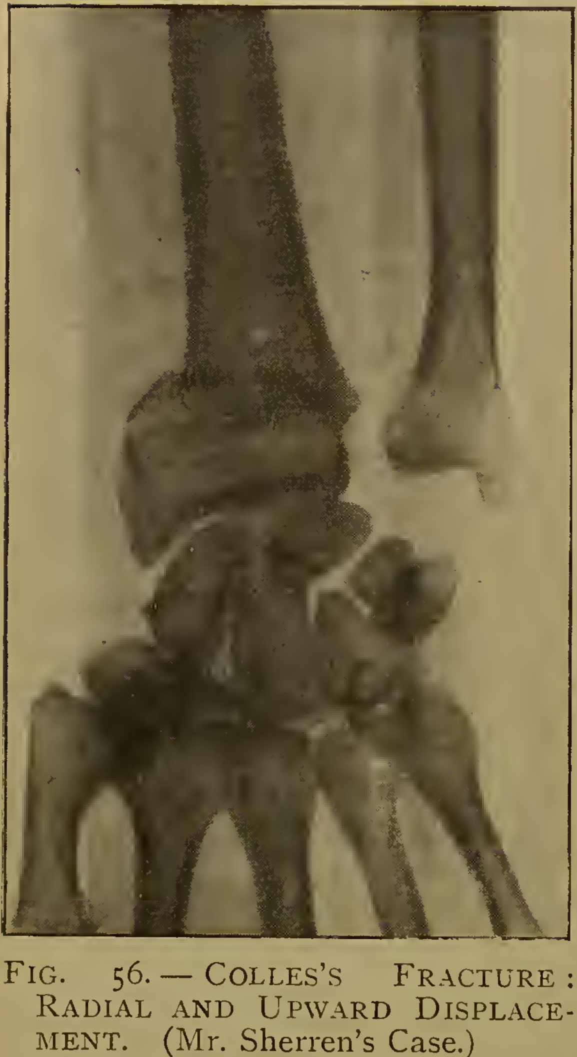

FIG. 56.—COLLES'S FRACTURE: RADIAL AND UPWARD DISPLACEMENT. (Mr. Sherren's Case.)

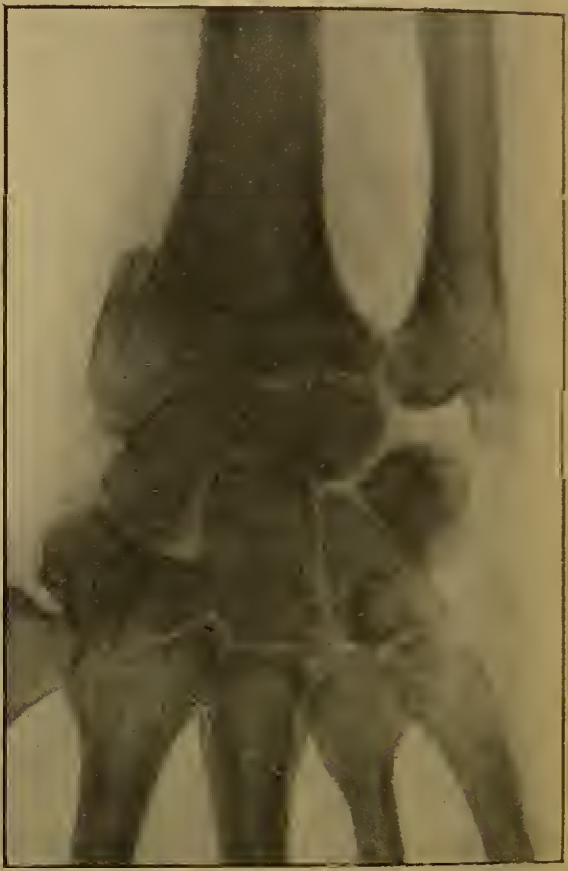

FIG. 57.—COLLES'S FRACTURE: RADIAL AND UPWARD DISPLACEMENT OF LOWER FRAGMENT; STYLOID PROCESS OF ULNA ALSO SEPARATED. (Mr. Dean's Case.)

nence, corresponding to the lower end of the shaft, is felt on the palmar surface. In some cases of impaction this deformity may be but little marked. The hand is adducted radially, the styloid process of the radius being at the same level, or even higher than that of the ulna, instead of below it as in the normal arm. This is the most constant and characteristic deformity. A prominence just below the site of fracture may also be felt on the radial side of the bone. For the same reason the styloid process of the ulna, if unfractured, is very prominent, whilst below it is a depression corresponding to the ruptured internal lateral ligament.

There may be much bruising and signs of local trauma. If no impaction be present crepitus may be obtained. Owing to the pain and the alteration in the position of the inferior radio-ulnar joint, there is often limitation of pronation and supination. In some cases with impaction the deformity is so slight that a radiograph is requisite to confirm the diagnosis.

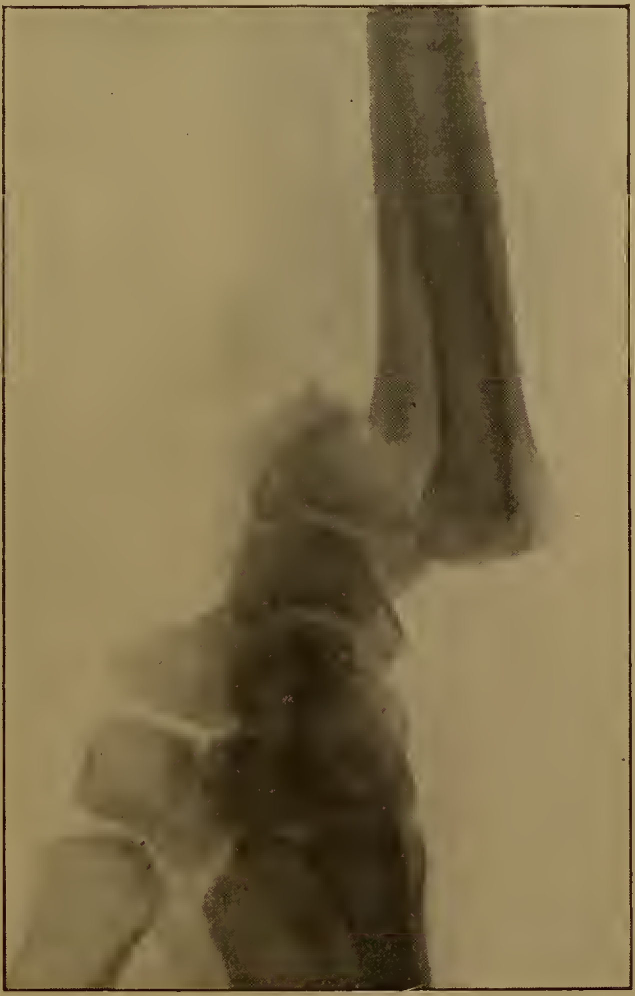

FIG. 58.—COLLES'S FRACTURE, SHOWING THE RARE FORWARD DISPLACEMENT OF THE FRAGMENT. (Mr. Sherren's Case.)

A variety of fracture somewhat similar to the above is that known as **Chauffeur's Fracture** [5]. It was described by Lucas Championnière in 1904, and is caused by a sudden wrench to the hand when the engine of a motor-car is being started. Sir George Beatson[1] says that it is caused by hyperextension of the wrist whilst in a position of ulnar deviation. It is most commonly caused by back-firing of the engine, leading to sudden and forcible backward rotation of the handle, which is being grasped by the chauffeur, and is generally found when the handle has been firmly grasped with the thumb beneath it and the knuckles above. For this reason the handle should be grasped with the thumb above and the knuckles beneath. The fracture passes obliquely through the lower end of the radius, starting on the outer side about $\frac{3}{4}$ inch above the styloid process, and entering the joint rather to the ulnar side of the mid-line (Fig. 59).

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[1] *Glasgow Med. Journ.*, September, 1908, p. 161.

There is usually but little displacement, the condition often overlooked and mistaken for a sprain. Crepitus may at times be present. It should be treated on the same lines as a Colles's fracture.

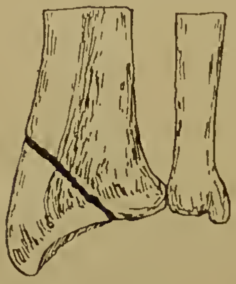

Fig. 59.—Line of Separation with "Chauffeur's Fracture."

Treatment.—The first consideration will be the reduction of the deformity. If impaction be present, as is so commonly the case, this will be fraught with considerable difficulty. The hand of the patient should be grasped in the corresponding hand of the surgeon, as though in the act of shaking hands. Forcible extension is now applied. The hand is first pulled directly downward, then gradually flexed towards the palmar surface, ulnar adduction being at the same time applied. The forearm during this manipulation may be supported on the surgeon's knee. If this method fail, an anæsthetic should be given, and the same movements or those of simple extension more forcibly applied.

When reduction has been brought about, fixation of the fragments will be necessary. Many forms of splint have been utilized for this purpose, but here, as elsewhere, it must be remembered that the splints are made rather to overcome individual deformities than to suit all cases of a given fracture; and provided that the surgeon realizes the deformity, several types of splint can often be adapted to overcome it. In the case of Colles's fracture, after reduction the radial deviation is the chief deformity which requires attention. It is best overcome by the use of Carr's splint, which consists of a straight wooden splint to fit the flexor surface of the arm, and hollowed out to receive the thenar eminence. At its extremity is placed an oblique bar which is gripped by the hand (Fig. 60). By this means the whole hand is deviated towards the ulnar side. The splint is fixed in position by two straps and buckles, so that it may easily be removed and massage commenced on the second or third day. The fingers are left free, and movements in them are encouraged. A posterior splint is usually worn at the same time, but it is unnecessary, and its use is more likely to be followed by stiffness. A bandage may be applied over the splint, and the arm carried in a sling.

The splint should be worn for three weeks, massage and passive movements being regularly carried out throughout this period, preferably for ten to twenty minutes every morning and evening. It is generally only possible in hospital practice, however, to apply it three times a week.

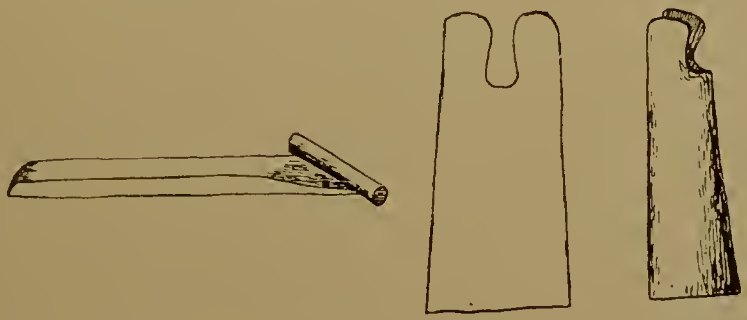

Fig. 60.—Carr's Splint (Left), and Moulded Poroplastic Splint (Left) for Use with Colles's Fracture.

A warning must be given here, that a left-hand splint be not used for a right-hand fracture. Impossible as it may seem, cases of this mistake do occur, with the result that the deformity of the fracture is greatly accentuated, and severe disability follows.

Instead of this splint, simple antero-posterior wooden ones may be used. These should be well padded to fit the arm, and dusted over with boric acid powder. They should be of such a length that the one on the extensor surface reaches from the elbow to the heads of the metacarpal bones, the one on the flexor surface reaching to about the middle of the metacarpals. The fingers are thus not included, free movements of them being permitted; otherwise tendon adhesions and contractions will be very likely to follow. The splints are fixed by straps and buckles, and not too tightly, lest ischæmic muscular contraction follow. A sling must be worn. If straps be used instead of adhesive plaster, they may be easily loosened if subsequent swelling of the limb make the primary fixation too tight, while the extensor splint is easily removed for massage, the limb being supported by the palmar splint in the meanwhile. Massage should be begun on the second or third day, and should at first be gentle. In a week the whole arm may be massaged, and both splints removed, to allow passive movements of the wrist, the fragments being supported by the masseur's other hand. Gentle pronation and supination are commenced at the same time. These splints should never be worn for more than three weeks, but the sling is continued for another two weeks.

Another useful form of retentive apparatus is a piece of poroplastic material cut as figured (Fig. 60). This is fixed to the radial side of the arm, so that the base of the thumb fits into the groove, the hand thereby being deviated to the ulnar side. The longer pieces should not reach beyond the heads of the metacarpals on the dorsal surface, or 1 inch above this on the palmar surface. The splint should be carefully padded and fixed with straps, the arm being carried in a sling. The after-treatment will be similar to that with the other forms of splint.

It is often advised that no splint be used, the arm being simply supported in a sling, which in this case should never reach beyond the wrist, so that the hand drops downwards—*i.e.*, towards the ulnar side; but although this overcomes the deformity, there is no fixation of the fragments, and every movement causes jolting. It should therefore not be adopted. In old cases with malunion, an open operation will be requisite if there be much functional disability. A long incision should be made over the outer side of the radius, the bone chiselled through in the line of the fracture, the lower fragment replaced and fixed. Passive movements are commenced in a few days.

Separation of the Lower Radial Epiphysis.—A centre appears for the lower epiphysis at the age of two to three years, and unites with the shaft at about the twenty-second year. The epiphysis includes the articular surfaces both for the carpus and the lower end of the ulna (Fig. 50). Separation is rare before the age of ten, and usually occurs at about seventeen or eighteen (J. Hutchinson).[1] It is nearly always due to direct violence, most commonly to a fall on the hyper-extended hand while in a position of radial adduction. The epiphysis is nearly always displaced backwards, and may be associated either with a fracture of the styloid process of the ulna, a fracture of the lower portion of the shaft of the ulna, or separation of the ulnar epiphysis. Very rarely it may be displaced forwards. If displaced backwards, there is the same radial adduction as in a Colles's fracture, but the backward rotation is usually less, so that the articular surface still looks directly downwards instead of downwards and backwards. For this reason the prominence on the extensor surface, due to the upper edge of the epiphysis, is more marked than in that condition, as is also that prominence on the flexor surface, due to the presence of the lower end of the diaphysis. This forms a sharp projection which may press upon or injure the arteries or nerves, and thus necessitate open operation. Separation is rarely sufficiently complete to allow the fragments to override.

The injury to the epiphyseal line may be sufficient to cause future loss or decrease of growth, in which case, owing to the unrestrained growth of the ulna, the forearm will become curved, the radius occupying the concavity.

Treatment.—An anæsthetic must be given, and the deformity carefully corrected by means of extension and pressure over the displaced epiphysis. Extension will be most needed on the radial side, owing to the tilting of the epiphysis, and the hand should therefore be pulled over to the ulnar side. When all deformity is overcome, the lesion should be treated on the same lines as a Colles's fracture. If subsequent cessation of growth occur, it may be necessary to remove a portion of the ulna to overcome the curvature.

Both Bones.

Both bones of the forearm may be fractured at the same time. This may take place in the middle of the forearm, when it is due either to direct or indirect violence, or near the wrist, which is rarer and generally due to direct violence.

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[1] *Brit. Med. Journ.*, July 16, 1887.

In the Middle of the Forearm (Fig. 61).—The bones are generally fractured at about the same level, and the fracture may be transverse, in which case the four ends tend to approach one another, and cross-union may thus occur. The lower part of the arm will drop, and thus the axes of the fragments differ. If the line of fracture be oblique there will be considerable overriding. The position of the upper fragment of the radius is all-important here, as in cases of fracture of that bone alone. If the fracture of the radius be above the pronator, it will be supinated; if below, midway between pronation and supination.

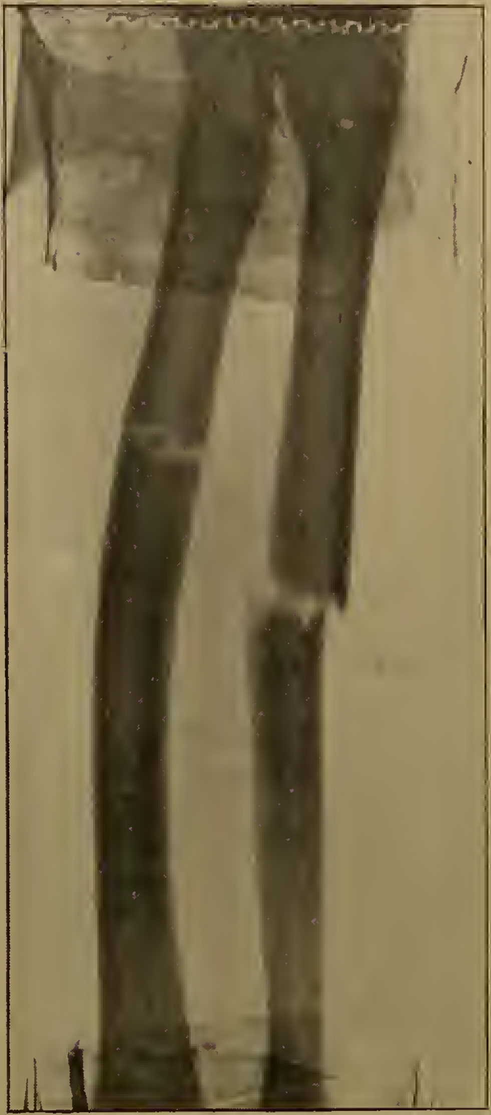

Fig. 61.—Fracture of Both Bones of the Forearm in their Upper Part. (Mr. Furnivall's Case.)

Rarely the bones may be fractured at different levels.

Symptoms.—The affected arm will be swollen and bruised. There will be complete loss of power in it, and the patient will support it in the unaffected hand. Deformity, as shown by bending of the arm, is very marked. Excessive movement accompanied by crepitus is easily obtained, while alterations in the line of the bone may, in the case of the ulnar, be felt subcutaneously.

Treatment.—It is important that the bones of the forearm be securely fixed, so that not only are movements of flexion and extension abolished, but also those of pronation and supination. For this reason angular splints must be used, and carried sufficiently far up the arm to obtain a good grip of the humerus. As in the case of fractures of the radius alone, the lower fragment of this bone must always be brought into apposition with the upper. Thus, if the fracture be above the pronator radii teres, the forearm should be fully supinated, and maintained in this position by a posterior angular splint. A metal splint will be found most serviceable, with an alterable angle at the elbow-joint. The splint must be about $\frac{1}{2}$ inch wider than the arm, so that the bandages do not compress the bones and bring them into apposition when cross-union is likely to occur. The posterior portion should reach down only as far as the wrist, so as to allow free movements of the fingers. If difficulty is experienced in maintaining supination of the arm with the posterior angular splint alone, an anterior one may be added. The splints are well padded, and fixed with straps and buckles. A sling must also be worn.

If the fracture be below the insertion of the pronator, an internal angular wooden splint should be applied in the same way as for a fracture of the radius alone, the arm being kept midway between pronation and supination.

In either case care must be taken that the splints are not applied too tightly, as in this position ischæmic contraction is very prone to occur. The limb must always be examined the day after the application of the splints, and if straps are used this fault is readily overcome.

Massage should be commenced in four days, the splint, or if two are used one splint, being maintained in position. Passive movements of the fingers are commenced at the same time. In about a week the splints may be removed daily for massage and reapplied, gentle movements of the elbow being also begun. Pronation and supination are added at the end of three weeks, and gradually increased. After four weeks the splints are omitted, the arm being carried in a sling, and massage and movements, now both active and passive, continued. Light work may be allowed at the end of six to eight weeks. Cross-union or malunion will require open operation (see Complications).

Near the Wrist.—Here also the two bones are usually fractured at the same level (Fig. 62). These fractures are generally due to direct violence, and are thus associated with a good deal of local bruising and swelling. The two lower ends tend to approximate one another from the action of the pronator quadratus. There may also be a considerable lateral displacement due to the injury. Antero-posterior splints should be applied after reduction, and the condition then treated on the same lines as a Colles's fracture.

PROGNOSIS.

Fractures of the olecranon process, if treated by open operation, are nearly always followed by extremely good results. In old people, however, a certain amount of osteo-arthritic trouble is almost certain to follow. If passive movements be commenced early, the patient is generally able to resume his work at the end of six weeks. If not operated upon, he is almost certain to obtain only fibrous union with great weakness of extension. Fibrous ankylosis is much more likely to occur, owing to the prolonged fixation when blood is effused into the joint.

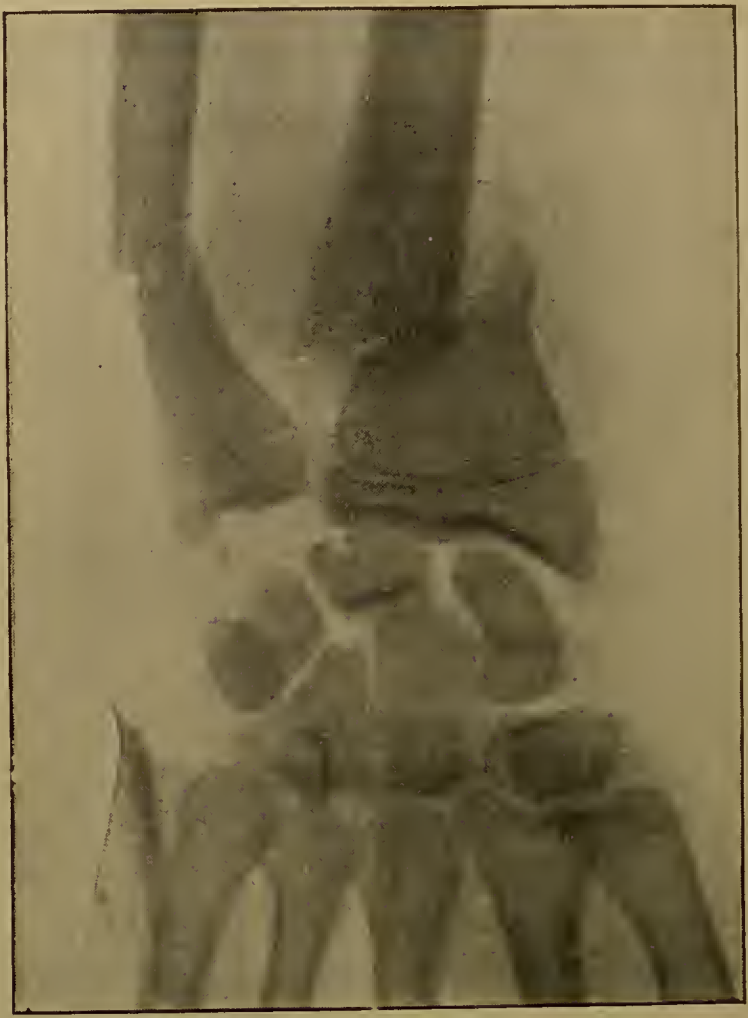

FIG. 62.—FRACTURE OF BOTH BONES OF FOREARM LOW DOWN.

Fractures of the coronoid process give very unsatisfactory results. The joint is injured, and thus arthritic changes are likely to ensue. Absolute apposition is almost impossible, and thus fibrous union, with consequent weakness, will follow. Excess of callus formation will often cause limitation of movement. Fortunately these fractures are rare.

Fractures of the shaft of the ulna alone are associated with but little deformity—hence complications are rare. Fixation is easily obtained, and thus, if care be taken with the treatment, especially as regards massage and passive movements, firm union should have taken place at the end of four weeks, when very light work may be allowed. At the end of six to eight weeks the patient may, in most cases, return to his ordinary work. Occasionally slight pain may persist even for a few months. If this fracture be associated with a displacement of the head of the radius forward, the outlook is not nearly so good. Replacement of the two deformities is difficult, and, even if successfully accomplished by manipulation, is often followed by long-continued pain on rotation, which movement may also be limited. If open operation be required, convalescence is often considerably prolonged. Limitation of the movements of rotation may persist for some months, but if passive movements be persevered with this will generally be overcome. The younger the patient, and the earlier movements are commenced, the better will the outlook be. In older patients permanent arthritic changes causing pain on movement are likely to follow. Old-standing cases, however carefully treated by reduction of the deformity by open operation, by excision of the head of the radius and removal of excess of callus, although greatly benefited, are very unlikely to be followed by normal use of the limb, although by this means the patient may be enabled to undertake light work. Fractures of the head of the radius in younger patients may be followed by extremely good results if treated by open operation, followed by early passive movements, the patient being able to use his arm perfectly in three to four weeks.

In older patients changes will take place in the articular surfaces, and limitation of movement with pain be almost certain to follow. Such a condition is often not only permanent, but it may even be progressive, and, if involving the elbow-joint, marked ankylosis may follow. Fractures here, and of the neck, may involve the posterior interosseous nerve and cause extensor paralysis.

If the shaft of the radius be alone fractured, the prognosis will depend upon the position, and will be much better if the fracture be situated below the pronator. In this position perfect function with no symptoms often results after five to six weeks. When above the pronator, fixation in a position of full supination is difficult, and a certain amount of loss of the power of rotation is very likely to follow. If malunion of a rotatory nature, or due to cross-union has occurred, good results are difficult to obtain. Even with open operation, with fixation, and with prolonged and careful massage and passive movement, there is almost certain to be considerable subsequent loss of movement, and hence early diagnosis of the site of the fracture is very important.

With a Colles's fracture the results are very variable, and will depend largely upon the age of the patient and the preliminary treatment. In some cases with but slight displacement, perfect functional results follow with careful treatment, or sometimes even with no treatment at all. In others, especially older people with much displacement, weakness of the limb may be very persistent, or even permanent. In all cases there is a tendency to limitation of movement, especially as regards flexion of the wrist. This is best prevented by overcoming all backward rotation of the lower fragment, but it is not uncommon even where all care has been exercised. It is best prevented or overcome by the regular use of passive movements. Subsequent œdema, especially after work, may persist for three to four months, but is less likely to be marked if a course of massage is carefully carried out. If present, it is best overcome by the same method of treatment. Alterations in growth after separation of the lower epiphyses have already been considered.

When both bones are fractured, complications are more likely to ensue, the displacement being greater; non-union, from the interposition of soft structures, is more probable, while malunion from fusion of all four ends is more common than with a single fracture. If good apposition is obtained, a perfectly useful arm may result in about six weeks. It will probably be weak, however, and two to three months may pass before it can be used for hard work. If poor apposition has resulted when the fracture is above the pronator, a marked loss of rotatory power will follow, and, in spite of open operation with passive movements and massage, it is unlikely that full use of the arm will be gained—that is, sufficient to allow the heavy work of a labourer to be undertaken, although for lighter work no disability may be noticed.

Fractures of the forearm are more likely than any others to be followed by a condition of ischæmic contraction, and although, with the less prolonged use of splints and the general recognition of the value of massage and passive movements, such a result is becoming more rare, yet cases do undoubtedly occur which have no bearing upon the treatment, and this condition must therefore, in compensation cases at least, be regarded as a real complication.

CHAPTER XI

FRACTURES OF THE CARPAL AND METACARPAL BONES AND PHALANGES

Carpal Bones.—Fractures of the carpal bones are unusual, and generally due to direct violence, such as severe blows to, or crushes of, the wrist, in which case several bones are injured, the fractures often being compound. If one bone alone be injured, the scaphoid, or os magnum, is the one most commonly affected. In the case of the scaphoid, the fracture passes between the articular surfaces for the radius and trapezoid bone. In both cases the injury generally follows direct violence. If several bones are crushed, no difficulty in the diagnosis will arise; the soft tissues may be much lacerated, and portions of broken bone be felt at the bottom of the wound, or protrude from it. Where the injury to the soft tissues is less there will be much swelling, loss of power, and crepitus on movement at the wrist-joint, the exact amount of damage being made evident by a radiograph. When one bone is alone fractured, diagnosis will be extremely difficult, and the condition is likely to be mistaken for a simple sprain. It has, in fact, only become well recognized since the advent of radiography. There will be localized swelling, tenderness on pressure, and pain on movement at the wrist-joint. Displacement is very slight.

Treatment.—If a severe lacerated wound be present, the question of amputation will have to be considered (see Complications). If it be decided that amputation is unnecessary, the wound must be thoroughly cleansed, any loose pieces of bone removed, a small drain inserted, and the wound sutured. An anterior splint reaching from the middle of the forearm to the heads of the metacarpals is applied. The tube, if the wound remains clean, is removed on the second day, and gentle passive movements commenced on the fourth day. The splint is removed in ten days, massage and passive movements being continued, and the arm carried in a sling for a further week. By this means the tendency to the formation of adhesions may be overcome.

With a severe simple crush, similar lines of treatment are carried out, passive movements being commenced early. If only one bone be fractured, it is advisable to fix the wrist for a week by an anterior wooden or a shaped poroplastic splint. Massage and passive movements of the fingers are begun in a few days, and of the wrist at the end of a week.

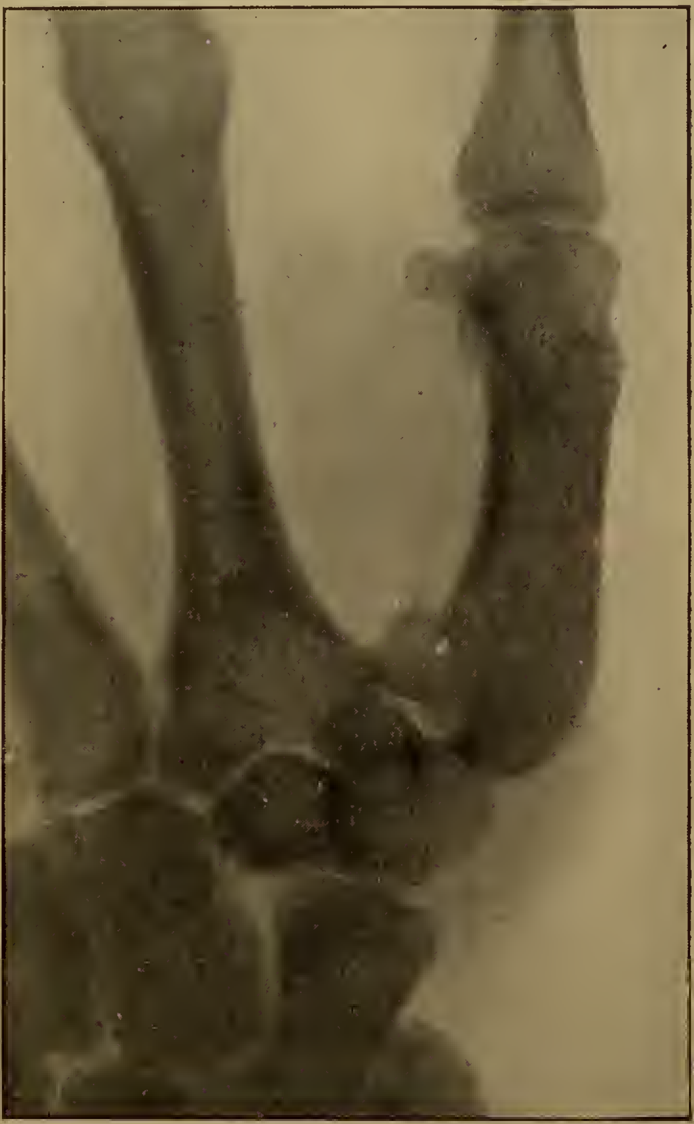

FIG. 63. — FRACTURE OF BASE OF FIRST METACARPAL—"BENNETT'S FRACTURE." (Mr. Sherren's Case.)

Metacarpal Bones. — Adequate recognition of these fractures dates from the introduction of X rays as a diagnostic factor. The first good collection of cases was made by Russ,[1] who collected twenty-seven, while Mackenzie[2] has given a good account of the condition based on sixty-seven of his own cases. They may arise from direct or indirect violence, and either extremity or the shaft may be fractured.

At the Base.—Fractures at the base of the bone are more common in the case of the first metacarpal. In this bone also the epiphysis is situated at this extremity, and may be partially or completely separated. More commonly, however, there is an oblique fracture of the proximal end, which passes backwards and involves the joint (Fig. 63), a condition known as "Bennett's Fracture," being first described by E. H. Bennett.[1] A precisely similar type of fracture may occur at the base of the fifth metacarpal bone. Burrows[2] has shown that this variety of fracture is by no means uncommon. It may be due to direct violence over the base of the first metacarpal bone, but is more commonly due to indirect violence applied along the shaft of the bone, such as a blow on its head from an ill-directed "punch" at a hard object. In such cases the patient complains only of tenderness and swelling at the base of the thumb, with pain on movement, these symptoms dating from the injury. In others the metacarpal shows some backward displacement, and is not uncommonly mistaken for a backward dislocation. The condition will be made clear by a radiograph.

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[1] *Annals of Surgery*, 1906, p. 288. [2] *Practitioner*, October, 1908, p. 517.

Treatment.—If there be no displacement, the thumb should be immobilized by either a straight anterior splint reaching from 3 inches above the wrist to the tip of the thumb, and strapped in position, or by the application of a moulded poroplastic casing. Whichever is used should be kept in position for three to four days, when all swelling will have disappeared. Passive movements and massage are now commenced, the splint being reapplied until the end of ten days, after which the thumb is bandaged over cotton-wool for another week to prevent excessive use.

If there be overlapping, extension may be applied by strapping the thumb over a palmar pad, as in the case of a fracture of the shaft.

Of the Shaft.—Fractures of the shaft may be multiple or single. They were formerly regarded as being most commonly due to direct violence (Hamilton[3]). There is no doubt that a large number are so produced, either several bones being fractured, as when the injury results from a crush or a heavy weight falling upon the back of the hand, or a single bone being broken across, as from a blow on the dorsum of the hand with a stick or buckle of a belt. More commonly they are due to severe violence upon the head of the bone, as by a hard "punch" on an opponent's head or jaw. For this reason Burrows[1] has given them the name of "punch fractures," and it is remarkable how constant it is to obtain this history of the patient having punched another man on the head or jaw, and so sustaining this injury. The second or third metacarpals are generally affected (Figs. 64 and 65).

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[1] *Brit. Med. Journ.*, July, 1886, vol. ii., p. 12.

[2] *Ibid.*, March 28, 1908.

[3] *Fractures and Dislocations*, 1875, 1st edit.

In many cases there may be but few signs, the patient complains of tenderness on the dorsum of the hand with pain on movement, and there is slight swelling here. In these cases the diagnosis will probably only be made with the aid of radiography. Much more commonly, however, there is a very characteristic deformity. The blow being applied to the head of the bone, this is doubled up, its convexity being increased, the deformity, according to Cooper,[2] being maintained by the action of the interossei. The result of this is that in the early stages there is a definite prominence on the dorsum of the hand, due to the angle at the line of fracture, whilst the head of the bone is markedly depressed, the knuckle

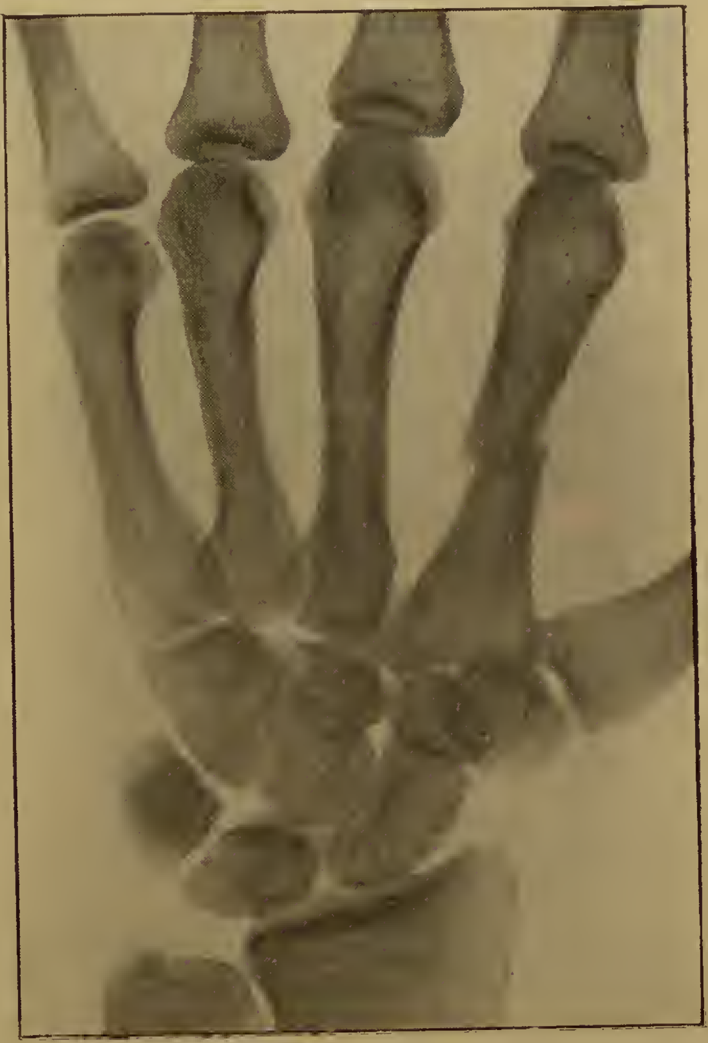

FIG. 64.—FRACTURE OF SHAFT OF SECOND METACARPAL—"PUNCH FRACTURE." (Mr. Lett's Case.)

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[1] *Loc. cit.*

[2] Hamilton's *Dislocations and Fractures*, 8th edit., 1891.

appearing to be driven in. Sometimes a certain amount of lateral displacement may also be present. Within a few days great swelling occurs on the dorsum of the hand. By firmly gripping the affected finger, applying extension along it, and at the same time exerting pressure upon the prominence on the dorsum of the hand, the deformity is easily overcome, crepitus being obtained. Increased mobility at the site of fracture may be elicited in a similar manner.

Treatment.—Deformity is readily overcome by gripping the finger and applying extension, but more difficulty is experienced in maintaining this position. The most satisfactory method is to take a three-inch rolled-up bandage, the diameter of the roll being about 1½ inches. This is placed in the palm of the patient's hand, he gripping it with the unaffected fingers. The affected finger is now extended, and the phalanges then flexed round the bandage, so as to lie in line with the other fingers and also to grip the bandage. Success is shown by the fact that the knuckle of the affected finger remains unsunken. The fingers are fixed in this position by narrow lengths of strapping. These start on the dorsum at the level of the wrist, pass down parallel with the extensor tendons over the flexed fingers, and up to be attached to the palmar surface of the wrist. A pad may be applied to exert pressure on the dorsum if desired.

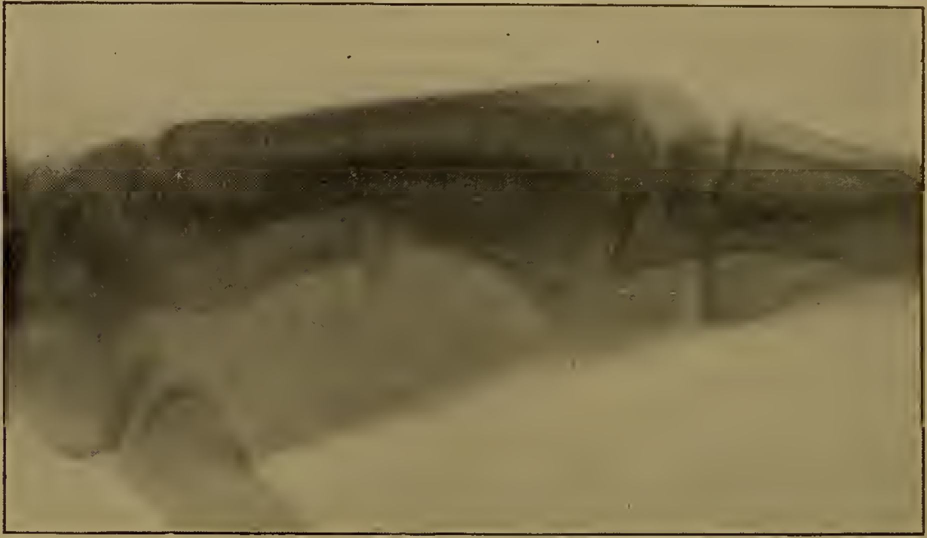

FIG. 65.—FRACTURE OF SHAFT OF SECOND METACARPAL—"PUNCH FRACTURE"—SHOWING PALMAR FLEXION OF DISTAL FRAGMENT. (Mr. Lett's Case.)

Mackenzie,[1] instead of the bandage, advises a round handle of wood 1½ inches in diameter, covered in cotton-wool and dusted with boric powder. Russ[2] used four slate pencils; two were applied, one on either side of the finger, on the dorsum, and two, one on either side on the palmar surface. These were strapped firmly in position to the hand, deformity having been overcome by extension. The finger was fixed in the extended position by strapping the phalanges firmly to the four surrounding pencils. This generally fails to keep the fragments in good position, and is not nearly so satisfactory as the palmar pad, which gives equally good results in the case of the first metacarpal.

At the end of a week, if swelling has not necessitated its earlier removal, the strapping is taken off, and massage and gentle passive movements begun. The apparatus is reapplied until the end of a fortnight, at which time, if good apposition is maintained, it may be left off and active movements commenced, the hand being bandaged over wool, with the fingers free, for another week, active and passive movements in them being persevered with.

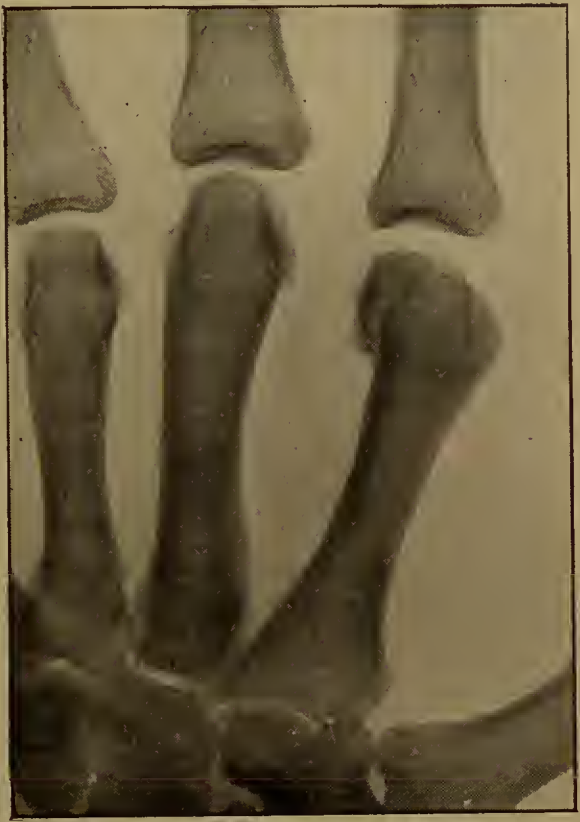

FIG. 66.—FRACTURE OF HEAD OF SECOND METACARPAL. (Mr. Furnivall's Case.)

At the Head.—Fractures at the head of the metacarpals are more common in the case of the second and third (Fig. 66), and are generally due to direct violence, but they also may result from a punch. In the same way separation of the epiphyses, which in the second, third, fourth, and fifth metacarpals are situated at the distal end, may take place.

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[1] *Practitioner*, October, 1908, p. 51.

[2] *Annals of Surgery*, 1906, p. 288.

Displacement is as a rule slight. At times the distal portion of the head may be impacted, or a comminuted fracture be present.

There will be pain, swelling, and tenderness, over the head of the affected bone. Sometimes increased mobility with crepitus will be obtained on moving the finger laterally.

Treatment.—If there be no displacement, it will suffice to immobilize the finger with a palmar splint for one week. This should reach from the wrist to the tip of the finger, be well padded, and fixed with strips of adhesive strapping. At the end of the week the splint is removed and gentle massage and passive movement commenced, the splint being replaced for another week. If there be comminution and shortening, extension may be applied by the use of a palmar pad, as in the case of fractures of the shaft.

PROGNOSIS.

If properly treated, so that replacement is good, and passive movements are commenced early, the results are usually very satisfactory. In the case of a fracture of the shaft of the bone, the patient should be able to return to his work at the end of four weeks, and all movements should be perfectly free. In the case of fracture of the base or head, poor results may at times follow, in spite of the most careful treatment. Ankylosis of the affected joint may take place, although this is much less likely if passive movements be commenced early.

Traumatic alterations in the joint surface, or the onset of subsequent arthritic changes, may lead to much localized pain.

If untreated, or badly treated by prolonged fixation in an abnormal position, the results are generally very bad; this is especially so if more than one bone be broken. Adhesions of the bones to one another, and implication of extensor and flexor tendons, will lead to much limitation of movement, which it will be difficult or almost impossible to overcome by subsequent treatment. Adhesions are more likely to follow if the fracture be compound.

Atrophy of the muscles of the thenar and hypothenar eminences, or of the interossei, may at times follow these fractures.

Phalanges.—Fractures of the phalanges are not uncommon, and are usually due to direct violence. The proximal phalanx, being the longer, is more prone to be affected, in which case the fracture is more commonly transverse through the middle of the shaft.

The distal phalanges may be fractured by a crush, when the lesion is often comminuted, and may involve one of the interphalangeal joints. If the joint be involved, there will be a great tendency for ankylosis to occur. These fractures, being due to direct violence, are often compound, the soft tissues being so injured and infected that subsequent amputation may be called for (see Complications).

Treatment.—If simple, any deformity may be readily overcome by manipulation and extension. The finger is then fixed in position on a narrow palmar splint, reaching from the wrist to the extremity of the finger. This is held in position by bands of adhesive strapping, which are so applied as to firmly fix the individual fragments. The splint is removed at the end of the first week, and gentle passive movements commenced. These are specially requisite if a joint be involved. The splint is reapplied and kept in position for another week. The patient will not be likely to be able to return to his work until three to four weeks after the accident. Instead of the palmar splint, a moulded tin one may be used.

If the fracture be compound, the wound must be carefully cleansed, drained, and closed in the rest of its area. A splint is then applied as before. Suppuration is very likely to take place here, which will probably infect the fractured bone and lead to necrosis of the part. This will greatly prolong convalescence, and increase the tendency to the formation of a stiff finger.

CHAPTER XII

FRACTURES OF THE PELVIS

FRACTURES of the pelvis are not common; they are most often seen in severe smashes, when fractures of other bones may be present, the condition of the patient being so serious that it may be difficult to determine the extent of his injuries. In such cases the pelvic arch as a whole is broken, and injury to the pelvic viscera is very likely to take place. Slighter trauma may give rise to fractures of the individual bones, when the viscera usually escape injury.

As a Whole.—This type of injury is brought about by severe trauma, generally such as tends to flatten the pelvis from before backwards—for example, crushes between the buffers of a train or run-over accidents. The line of fracture here tends to follow more or less the obstetrical oblique diameter; thus, the ilium is torn from the sacrum, not directly at the sacro-iliac synchondrosis, but rather outside it, a portion of the ilium remaining attached to the sacrum. In front, but on the other side, the fracture passes through the obturator foramen, the horizontal ramus of the pubis and the ascending ramus of the ilium being divided. At times such a fracture is bilateral, when the sacrum tends to be displaced forwards, and the separated symphysis of the pubes backwards, whereby the bladder, urethra, and rectum, are very prone to be injured. The bladder and urethra are extremely likely to be torn or ruptured; even if the fracture be only unilateral, the former may be ruptured if full at the time of the accident, at some distance from the bone lesion, and apart from laceration by the fragments. The urethra is generally injured, as it lies beneath the symphysis in its membranous part. Deanesly[1] records cases where the urethra has been completely torn across at the apex of the prostrate. These have occurred from trauma applied to the sides of the pelvis, and he regards them as depending upon lengthening of the antero-posterior diameter of the pelvis, the arch being flattened from side to side. The urethra, being fixed by the triangular ligament, is then pulled forward and torn off the apex of the prostate, which gland, if the pubo-prostatic ligaments be torn, together with the bladder, drops back into the concavity of the sacrum, so that much separation of the two ends of the urethra takes place. In women the vagina may be lacerated or torn, the anterior wall being most liable to be affected. In other cases the iliac or femoral vessels, or their branches, may be injured, and much loss of blood result. The cutaneous and subcutaneous tissues are often bruised and lacerated.

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[1] *Lancet*, January 12, 1907.

Symptoms.—The patient will be found in a condition of severe shock and collapse. There will be great pain and tenderness around the pelvic girdle, increased on movements of the trunk and limbs and by pressure upon the crests or spines of the ilium. Walking will be impossible, and in the less severe cases, where the patient may have been able to attempt this, he will state that such attempts are accompanied by severe pain, as though his pelvis were falling to pieces. The overlying soft tissues will show bruising and laceration. If a large vessel be ruptured, the patient will show signs of loss of blood, while locally, and more commonly in one or other Scarpa's triangle, an ill-defined boggy swelling due to the effused blood may be visible.

If the urethra be ruptured, there will be an escape of blood from the penis, apart from micturition; generally the patient will feel a desire to pass water, and should this act be attempted, extravasation of urine, leading to swelling in the perineum, will result. If the bladder be ruptured either intra- or extraperitoneally, signs of this condition may be present; thus, in the former case the lower abdomen may be rigid, it will move but little on respiration, and tenderness on deep pressure will be present. With an extraperitoneal rupture, swelling above the symphysis pubis with tenderness will soon appear. In either case the amount of urine passed may be noticed to be very small, although none has been passed for some time, and there is a frequent desire to micturate. With the urine there may be a certain amount of blood, usually but small in quantity, and escaping at the end of micturition.

Injuries to the rectum will usually be associated with the early onset of peritonitis, if intraperitoneal. If extraperitoneal, there will be extravasation at first of blood, and later of pus, or even of fæcal material, into the perineum. Blood may escape from the anus.

Treatment.—In all cases attention must be first directed towards the bladder and urethra, and the patient should be warned not to attempt to pass urine if he has not already done so. By this means extravasation through the urethra can be prevented. If there be local bruising around any portion of the urethra, and blood escape from the penis, a rupture of the urethra is present. It is now sometimes advised that attempts be made to pass a soft rubber catheter, and, if this succeed, that it be tied in for three or four days. It is probably better, however, in all cases, even of partial rupture, to do an external urethrotomy, so that the extent of the injury can be investigated and corrected; for even partial rupture, without separation of the ends or extravasation of urine, may, if left, lead later on to severe traumatic stricture, or in the early stages be accompanied by local sepsis. Watson Cheyne and Burghard[1] advise that in very slight cases, where a catheter can be passed, this be done at regular intervals until the lesion be healed, but in no case should a catheter be tied in. In all other cases external urethrotomy should be performed.

With the patient in the lithotomy position, a median incision is made on to a Wheelhouse's staff. The condition of the urethra is now investigated. If only a partial rupture be present, it is carefully sutured with catgut. If the rupture be complete, the proximal end must first be discovered—a matter often of considerable difficulty. It may be searched for with a bougie, an assistant at the same time compressing the bladder so as to lead, if possible, to the escape of some urine, whereby the point of exit can be identified. In a few cases this may fail. If so, a suprapubic cystotomy must be done, and a catheter passed from above. The condition must never be left without finding the ends. A black gum elastic catheter, No. 10 or 12 in an adult, is now passed into the bladder, and the rent carefully sutured around it with catgut. If it be difficult to bring the ends together, the distal portion may be separated in part from the surrounding tissues, as advised by Cabot,[1] and, thus mobilized, brought readily back into contact with the proximal end. The wound is drained, and the catheter tied in position for a week, being then changed for a second, which is also tied in for a week, the urine meanwhile being kept aseptic with urotropine, and acid sodium phosphate given by mouth. Subsequent dilatation will be necessary.

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[1] *Manual of Surgical Treatment*, part vi., sect. ii., 1908, p. 363.

If the urethra be torn across at the triangular ligament, Deanesly[2] advises that an incision be made in the perineum, the proximal end of the urethra being found by pushing forward the prostate by a finger in the rectum. If this fail, suprapubic cystotomy, with the passage of a catheter, will have to be performed. The further steps of the treatment will be carried out on the same lines as above.

When a rupture of the bladder is suspected, it is often advised that the diagnosis be confirmed by the passage of a catheter, or by the introduction and subsequent withdrawal of a measured quantity of fluid. Such methods are, however, not free from error, and too much dependence should not be placed upon them. It is safer to rely on the symptoms.

An incision should be made into the prevesical space, if the rent be present here, all urine and blood-clot cleansed from the wound, and the extent of the rupture determined. If purely extraperitoneal it is accurately closed, unless the urine be septic, when the bladder should be drained. If the rent be closed, the prevesical space should always be drained, lest extravasation occur.

If the rent be intraperitoneal, the incision is made higher up, the peritoneum opened, urine swabbed out of the pelvis, the patient placed in the Trendelenburg position, the intestines protected with a sponge, and attempts made to close the rent with two layers of sutures, the inner of catgut and the outer of silk. If this can be accurately done, many surgeons close the abdomen without drainage, reserving this for cases where closure cannot be accurate or where the urine is septic, but it is probably safer to always use a drain. Little or no harm will be done by its presence, and the danger of extravasation will be greatly minimized.

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[1] *Annals of Surgery*, January, 1909, p. 86.
[2] *Lancet*, January 12, 1907.

The next question is whether a catheter should be tied in the bladder. Many cases do well without it, but here again, if care be taken to keep the urine aseptic by the administration of urotropine and acid sodium phosphate, no harm will be done, and there will be less danger of leakage through the rent, so that, in spite of the discomfort, it will be safer to adopt this procedure.

If the rent be both intra- and extraperitoneal, a combination of both methods will be adopted, the intraperitoneal rent being first closed. The peritoneum should here be closed, lest it be infected from the lower tube. Any loose and projecting fragments of bone will in any case be removed. Ruptured vessels must be cut down upon and ligatured or sutured.

If no complications be present, the patient must be kept in bed; the pelvis may be supported by a moulded poroplastic splint, or simply by a broad band kept in position by two sand-bags, one on either side.

If there be depression of the symphysis, this may, in a woman, be raised by a finger in the vagina, an anæsthetic being given. Firm union is slow, and the patient should not be allowed to sit up until after eight weeks. After two more weeks he may be allowed to walk gradually, but several more months will probably elapse before he is able to do this with comfort.

Of the Ilium.—Fractures of the ilium are due to direct violence, some portion of the crest being usually separated. Most commonly they are due to falls, the crest of the ilium striking the ground or some neighbouring object. A roughly triangular portion may be thus knocked off and driven inwards. In younger patients a similar injury may lead to separation of the epiphysis for the crest. In neither case is separation as a rule marked, owing to the wide attachments of the internal and external oblique and the transversalis muscles. If their aponeurosis be torn, however, the fragment may be drawn upwards and inwards and considerably displaced.

Either the anterior or posterior superior spines may be separated, most commonly from direct trauma, the former rarely from excessive muscular violence, in which case separation will be more marked.

Symptoms.—The patient will complain of localized pain at the site of injury, with swelling and tenderness. The portion of bone may be felt in an abnormal position, or movements accompanied by crepitus may be obtained.

Treatment.—If there be no separation, it will be sufficient to keep the patient at rest until union has occurred. He should be kept in bed, with the head somewhat raised, so as to relax the abdominal muscles. The pelvis should be fixed by a wide band over it, held in place on either side by a heavy sand-bag. Massage may be applied after a few days. In three weeks union will be sufficient to allow the patient to sit up on a couch, while in four weeks he may be allowed to walk. Severe muscular exercise should be prohibited for another two to four weeks. If there be much separation of the fragments, they should be cut down upon and wired.

Of the Ischium.—Fractures of this bone are limited almost wholly to the tuberosity, and are due to severe direct violence, such as falls in the sitting position or a kick. As a rule, owing to the wide muscular and aponeurotic attachments, separation is slight. If, however, these be torn through, the fragment may be drawn down by the long head of the biceps, the semimembranosus, and the semitendinosus.

Symptoms.—There will be signs of local trauma over the injured part; pain, increased on flexing the thigh; and tenderness. On flexing the thigh the tuberosity becomes more prominent, and in these cases it may be grasped, and movement of the lower portion, with crepitus, obtained. If separated, the fragment will by this movement be drawn downwards, and may be felt in its abnormal position. In doubtful cases radiography may help in the diagnosis.

Treatment.—If there be no separation, the patient should be placed in bed, the leg kept flexed at the knee, and extended at the thigh. It may be maintained in this position by a band round the waist, from the posterior part of which passes a loop, to be fixed round the ankle on the affected side. By this means tension of the attached muscles is overcome. In five to seven days very gentle passive movements and massage are commenced, the leg is straightened in three weeks, and the patient allowed to walk in four. Excessive exercise must not be permitted for another three to four weeks. If there be much separation, an open operation should be undertaken, or much weakness will result. The thigh being flexed, so as to make the tuberosity more prominent, a vertical incision 5 inches long is made over it. The gluteus maximus is pulled upwards and outwards, and the site of the injury thus laid bare. The fragments being brought into position by fully flexing the knee, they are united by wires, pegs, or screws. The latter will be found the most satisfactory. Passive movements are commenced in a few days, and the patient allowed to walk at the end of three weeks.

Of the Acetabulum.—Fractures of this portion of the bone are fortunately rare. They are of two varieties: The upper lip may be separated, usually from a fall on to the foot or knee, the head of the femur then rising up on the dorsum of the ilium, and giving rise to a direct dorsal dislocation. The second variety is due to very severe violence applied to the great trochanter, the head of the femur being thereby driven against the acetabular cavity, which may be simply splintered or even driven inwards, the head of the femur sometimes passing into the pelvic cavity. Such an injury may be associated with a comminuted or impacted fracture of the neck of the femur.

Symptoms.—The first variety will show shortening of the leg, with some inversion and flexion of the thigh. There will be much pain over the hip-joint, with tenderness, while movements at the joint, especially flexion and extension, will be much limited, owing to the absence of the fulcrum. The deformity can be readily overcome by extension, but tends to recur at once, a typical telescopic sign being obtained. Crepitus may be felt with this movement.

The second variety, otherwise known as "central dislocation of the femur," is very unusual. Halstead[1] states that only about fifty cases have been recorded. It was first described by Sir Astley Cooper in 1821. Other injuries of the pelvis will probably be present, and it will be associated with signs of severe local trauma. The trochanter of that side will be nearer the mid-line and at a higher level than usual. All movements at the hip will be limited, especially adduction and abduction, and associated with severe pain. The leg is adducted and the foot rotated in. The signs of a fracture of the neck may be present. When the head of the femur is driven through into the pelvis, injury of the viscera there may occur, and the head of the femur may be felt in its abnormal position by a rectal examination. In either case a radiograph will usually be necessary to make the diagnosis clear.

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[1] *New York Med. Journ.*, November 13, 1909.

Treatment.—When the upper lip of the acetabulum is fractured, it will be necessary not only to draw down the head of the femur, but to maintain it in that position until firm union of the acetabulum has occurred. For this reason an extension apparatus is applied reaching to one-half or two-thirds of the way up the thigh (see p. 21). A Liston's long splint is fitted, and the foot of the bed elevated on blocks. Weights are applied next day, and gradually increased until the head is held in position, as shown by a radiograph. Twelve to fourteen pounds weight, or even more, may be required. At the end of six weeks union should be firm, and passive movements should be gently begun. A Thomas's splint, with a patten on the sound foot to prevent pressure on the affected acetabulum, will be required for at least three months. Even with such methods failure of union often occurs, and attempt should then be made to fix the detached lip in position by open operation, the fragment being held in place by a fine screw or screws, extension being afterwards applied as before to prevent the mechanical union giving way.

When the acetabular cavity is fractured, attempts must be made to extract the head of the femur from the opening. The patient is anæsthetized, and firm extension made by two people, one pulling the leg directly downwards, the other directly outwards, by a towel placed round the thigh as near the groin as possible, counter-extension being made by assistants. Halstead found manipulations similar to those used for a posterior dislocation of the head of the femur most suitable to obtain reduction. When disengaged, constant extension must be made in both directions. The usual extension apparatus will be applied to the leg, while outward extension is made by a weight fixed to a band passing round the thigh high up, which runs over a pulley at the side of the bed. If the acetabulum be only splintered, without displacement of the head, extension should be applied in a similar manner, lest the head be drawn in by muscular contraction.

Passive movements should be begun in a week if there be no displacement, but not until the end of four to five weeks if the head has been driven in. In either case ankylosis of the hip-joint is likely to result. At the end of another one or two weeks the patient may be placed in a Thomas's hip splint, and allowed to walk with a patten on the sound foot, whereby no pressure is applied to the affected joint. The Thomas's splint will probably have to be worn for one or two months, attempts at walking being gradually increased, and massage and passive movements continued meanwhile.

Of the Sacrum.—Fractures of this bone are extremely rare. They may occur as a part of fractures of the pelvis as a whole when due to extreme violence, in which case they are often comminuted. At times the sacrum alone may be fractured, the lesion being then more commonly transverse and situated low down, close to the sacro-coccygeal joint. Such fractures are generally due to heavy blows over the lower part of the bone, such as kicks or falls from a height upon the sacrum. In either case the fragments of bone may be driven inwards and perforate the rectum, when severe sepsis is likely to follow, and will spread up into the pelvic connective tissue; or the skin and subcutaneous tissues may be lacerated, the line of fracture communicating with the exterior. Whether simple or compound, injury to the lower sacral and coccygeal nerves may follow, resulting either in severe and constant neuralgic pain or paralysis of the external sphincter.

Symptoms.—There will be signs of severe trauma over the lower end of the sacrum, and owing to the forward displacement of the lower fragment from the injury or from the forward muscular pull, an irregularity at the site of fracture may be felt. If an external wound be present, the fracture itself may be felt. If the rectum be perforated, blood may escape or be found on the examining finger, but the perforation is often too high up to be reached by it. In some cases the peritoneum may be torn and peritonitis result. Even in simple cases a rectal examination should be made, as the tilting forward of the lower end may be manifest, the coccyx being displaced forward and pushing upon the rectum. Later on this deformity, if not rectified, may give rise to difficulty in defæcation or pain on sitting.

Treatment.—These cases are so rare that no definite line of treatment can be laid down. If compound the wound should be enlarged, thoroughly cleansed, and the fragments fixed in their correct position by wiring, the wound then being drained for twenty-four to forty-eight hours.

In simple cases an attempt should be made to overcome the deformity by pressing the fragment backwards with a finger in the rectum. The patient is then made to lie on one or other side, so that the lower portion is not pushed forwards. In three to four weeks union will be fairly firm, and the patient may be allowed up, but care must be taken that in sitting down the fragment is not pushed forward. For this reason the patient should only be allowed to sit on a carefully-made air-cushion, so fashioned that no pressure is allowed.

Should difficulty arise later owing to displacement of the lower fragment forwards, a portion, or even the whole, of the coccyx may be excised.

If the rectum be injured, an open operation must be done, the rent in the rectum closed, the wound thoroughly cleansed, and the fragments fixed in position. This may be accomplished by a vertical incision passing along one side of the coccyx. The levator ani being divided, the fragment is pulled outwards, if necessary the incision being carried forwards into the corresponding ischio-rectal fossa. The rent in the rectum is now carefully closed with two layers of sutures, the rectum and wound thoroughly washed out, the fragments replaced, and if necessary sutured with wire sutures. The wound is now drained with a large tube packed round with gauze, and one or two approximation sutures inserted.

If the peritoneum be opened, laparotomy is performed with the patient in the Trendelenburg position, the peritoneum cleansed and the rent sutured, a large drainage-tube being passed down into the pelvis. The rest of the wound is closed. If the rent be extensive, the two above operations may have to be combined.

Of the Coccyx.—These fractures are produced in much the same way as those of the lower part of the sacrum—*i.e.*, from blows or kicks, or falls in the sitting position. In some cases they may arise during parturition. In either case the fragment is displaced forwards, partly from the direction of the violence, as in the first group of cases, but chiefly from the pull of the levator ani. At the line of the injury there will be pain and tenderness over the coccyx, increased on sitting down. In some cases the patient may complain of being unable to sit unless supported on an air-cushion. This pain may persist for months. There is often, also, pain on defæcation, owing to the forward displacement. Crepitus may be obtained if the fragment be grasped between one finger passed up the rectum and the thumb outside.

Treatment.—If diagnosed at the time of the accident, attempts must be made to replace the fragment backwards, a finger being placed in the rectum for this purpose. If this fail and symptoms continue, the coccyx may be cut down upon, wired in position, or removed entirely. This should not be done until three weeks after the accident, as not in all cases will symptoms persist. A vertical incision over the coccyx will be the most suitable, and after removal of the fragment the two halves of the levator ani should be sutured across the gap.

CHAPTER XIII

FRACTURES OF THE FEMUR

FRACTURES of the femur are relatively common. The proportion occurring at all ages is given by Morris[1] as 177 in 1,858 cases. They may occur at any age, but are much more common in elderly people, the neck of the bone being here chiefly affected. In younger people fractures of the shaft are more common, but the epiphysis of the head of the bone is probably more commonly separated either in part or completely than any other epiphysis in the body. Fractures of the femur may be due to direct or indirect violence. As in the case of other long bones, they are best divided into those of the upper extremity, those of the shaft, and those of the lower extremity (Fig. 67).

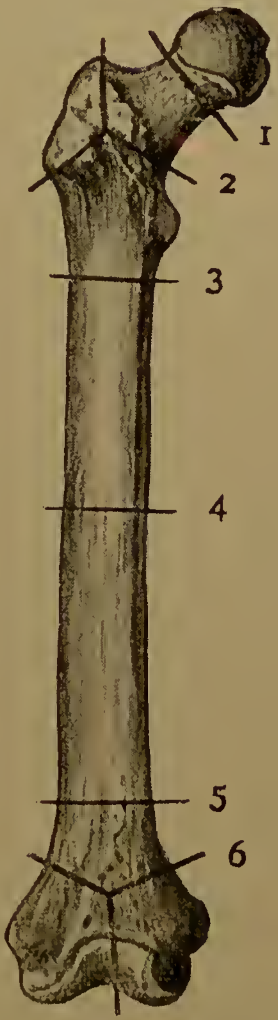

FIG. 67.—FEMUR, SHOWING SITES OF FRACTURE.

THE UPPER EXTREMITY.

Of the Neck [1].—A fracture in this position is much more common in elderly people, especially females. In them the bone here has undergone a good deal of osteoporosis, so that it is thinner and more cancellous than usual. At the same time the angle that the neck of the bone makes with the shaft is much less than is the case with younger people, and thus it will be less able to withstand violence directed along the long axis of the shaft. This type of fracture is most frequently due to slight indirect violence, a common accident being a fall off a chair or pair of steps whilst hanging up curtains, etc. In this case the patient falls only about 2½ feet, and alights with the feet on the ground, the thinned and weakened neck of the bone then giving way, usually close to the articular surface, the line of fracture being thus

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[1] *A System of Surgery*, Holmes and Hulke, 1883, p. 996.

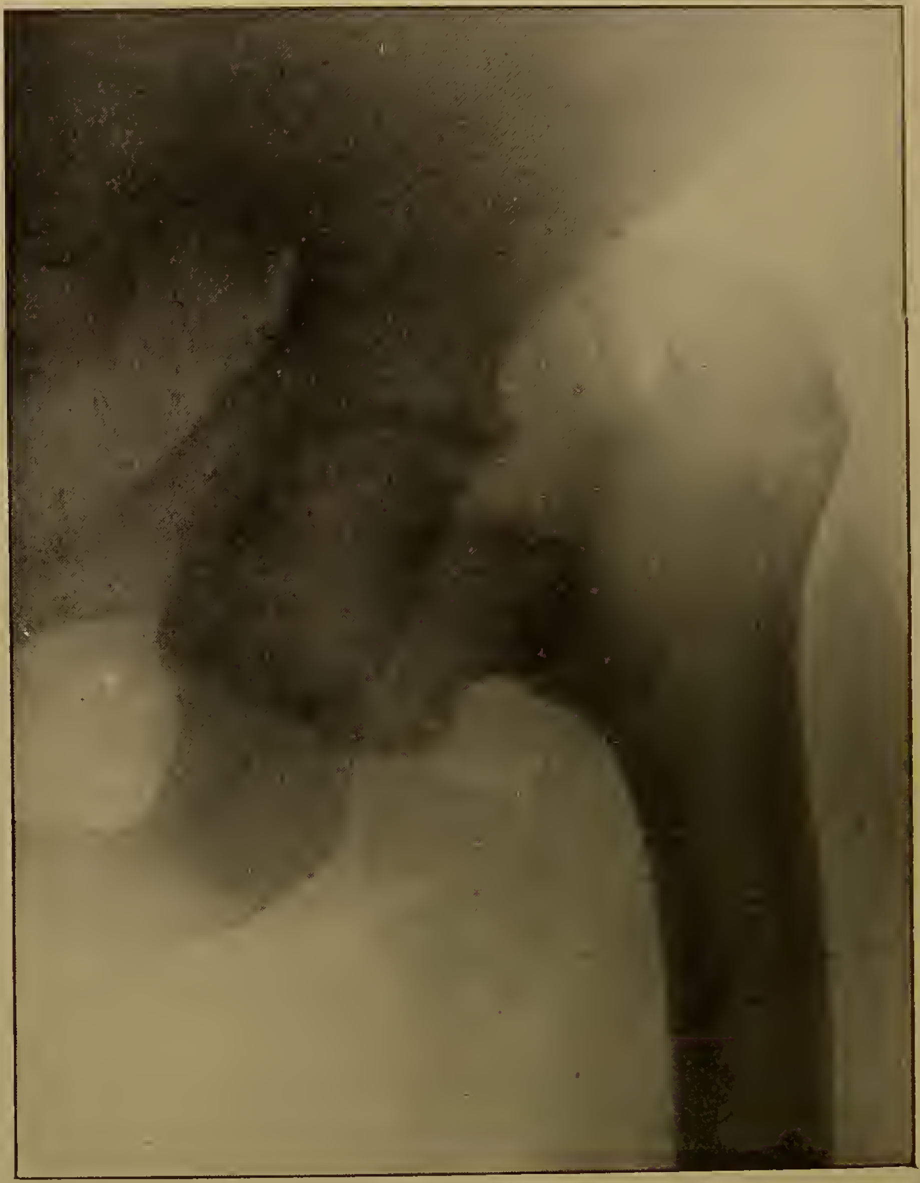

FIG. 68.—FRACTURE OF FEMUR THROUGH NECK.

wholly intra-articular (Fig. 68). Rarely this form of fracture may arise from blows upon the trochanters, in which case the fracture is more often comminuted. In the majority of cases separation of the two fragments is not very marked; they remain connected together, especially behind, by the periosteum covered with synovial membrane, which in this position is often loose, and raised into folds known as the "retinacula of Weitbrecht." The lower end tends to be drawn upwards by the glutei, and by the direction of the violence, but this displacement is not very extensive. In the rarer cases where the violence is applied over the trochanters, the neck may be impacted into the head, when this displacement is absent. The lower fragment is rotated outwards; the cause of this has given rise to some discussion. It is usually ascribed to the action of the weight of the leg, but is present even in impacted fractures where this factor can hardly be acting. Others regard it as due to the fact that absorption is more marked on the posterior surface of the neck, and fracture of this portion is always more extensive. That there is more damage in this area as a rule is certain, but whether it is due to increased absorption is doubtful. It may arise from the fact that even in the normal bone this aspect of the neck is slightly concave.

Symptoms.—The patient, usually an elderly female, will be unable to walk; she will give a history, generally, of some slight injury followed by severe pain in the hip-joint. On examination there may be some tenderness, bruising, and swelling, around the affected joint, but if the violence be applied to the foot this is often so slight as to be negligible. The leg is shortened; this is shown by the position of the malleoli, or more definitely by the fact that the great trochanter is above Nélaton's line (a line drawn from the anterior superior spine of the ilium to the most prominent part of the tuber ischii; in normal people this line should pass through the tip of the trochanter), or a line may be drawn vertically backwards from the anterior superior spine —the distance (Bryant's base line) between the tip of the great trochanter and this vertical line will be shortened on the affected side.

In the earlier stages the amount of shortening is rarely more than ½ inch; later it may be somewhat increased owing to absorption of the end of the lower fragment.

The leg and foot will be everted, the foot perhaps lying on its outer side. Movements will be decreased, especially flexion. The patient will be unable to raise the affected foot off the bed owing to the absence of the fulcrum. Crepitus may be obtained; this is, however, very difficult to localize, and in impacted cases will be absent. It some cases it may be possible to make out that the distance between the mid-line and the tip of the trochanter (Morris's mid-trochanteric line) is decreased on the affected side. The most important diagnostic factor is often, however, slackening of the upper part of the ilio-tibial band. The condition most resembling this accident is old osteo-arthritis of the hip, with a slight recent trauma causing some contusion but no fracture. Here there will be shortening and eversion from absorption. Crepitus from the roughening of the articular surfaces will be obtained, and loss of movement may be caused from the pain. Owing to the slow progress of the disease, however, the ilio-tibial band will have contracted down to its shorter state, and hence will still be tight.

In doubtful cases a radiograph will clear up the diagnosis.

Treatment.—In the common variety occurring in elderly people, any attempt to obtain firm fixation with consequent bony union has to be abandoned. If such patients be placed flat in bed and fixed in a splint, they within a few days develop a cough, with irregular temperature, slight delirium at night, and a rapid pulse. This increases, the delirium becomes worse, and extensive broncho-pneumonia develops, which generally proves rapidly fatal. For this reason they should only be kept in bed for about two days, and even then in a sitting position, so that the preliminary shock is decreased. At the end of that time some form of ambulatory treatment must be devised, which in the majority of cases only permits of fibrous union, although at times it may be bony. The most useful splint is a Thomas's hip-splint, which consists of a bar, moulded to fit the curves, passing from the level of the fifth or sixth dorsal spine down the mid-line of the back of the affected limb to about 3 inches above the ankle. It thus lies to one side of the spines. Curved arms project at right angles from it at its upper end, and to encircle the upper part of the thigh and lower part of the calf. From the upper arms straps pass over the shoulders (Fig. 69, A).

The patient is laid in this splint, and the arms are strapped round the body and limbs. It is now bandaged on, the end of the bandage being fixed to the splint in the dorsi-lumbar region, and passing round the unaffected side so as to prevent the vertical bar slipping round to the affected side of the body, which it is otherwise very prone to do. If the leg be bandaged also, it may be possible to overcome the eversion of the foot. An iron patten is fastened to the boot on the sound side, so that the affected limb hangs free from the ground, and the patient is allowed to walk with crutches.

This splint should be discarded when possible, but it may have to be worn for the rest of the patient's life. Hessing has invented a more efficient walking instrument, but the expense of it is so great as to debar it from general use.

In young adults the dangers of the prone position are not present, and thus attempts should always be made to obtain bony union. The shortening and eversion are best overcome and the limb fixed by the use of extension and a Liston's long splint, as advised for fractures of the middle of the shaft (p. 220). It will have to be kept in position for eight weeks or more, and must be followed by the application of a Thomas's splint for a further month. Consequently it is very prone to be followed by ankylosis of the injured hip-joint; moreover, the presence of the extension apparatus prevents the application of massage and passive movements to the knee and ankle joints, so that much muscular wasting, and even fixation of these joints, may often result, the latter condition being only overcome by prolonged subsequent movements and massage. It is claimed that these difficulties are largely prevented, and better results obtained, by the use of extension without a splint, as described on p. 22, but even here movements and massage cannot be easily applied.

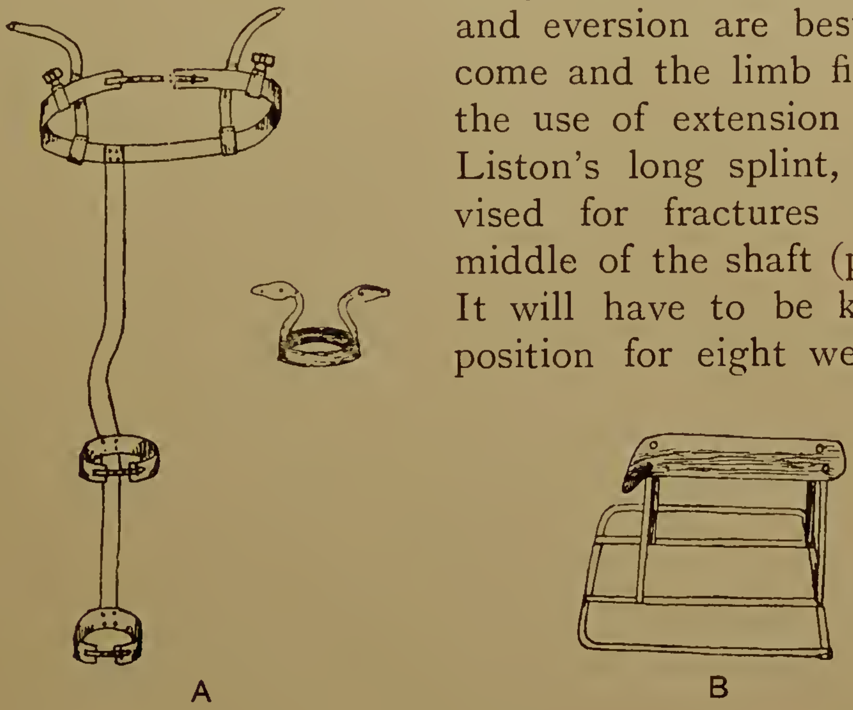

FIG. 69.

A, Thomas's hip splint and patten ; B, Openshaw's plaster rest.

In some cases fixation of the separated head has been attempted by operative means, whereby good apposition may be obtained, the complications of ankylosis and wasting being prevented by massage and passive movements. Openshaw[1] has recorded such a case with good results. Here the fragments were drawn into good position, a vertical incision made over the great trochanter, and a screw inserted through the neck into the head, its direction and depth being guided by an X-ray apparatus beneath the table. Watson Cheyne[2] has used a somewhat similar method, but which depends upon careful measurements to recognize the position and depth of insertion of an ivory peg, which is used instead of a screw. In either case the condition must afterwards be treated with a splint as above, but movements may be begun early.

Through the Trochanters [2].—This form of fracture, usually described as an extracapsular fracture of the neck, corresponds more or less in direction to the intertrochanteric line (Fig. 70). It is usually partly within and partly without the capsule of the joint, this latter structure reaching in front as low as the intertrochanteric line, whilst behind it only passes out as far as the middle of the neck. They are generally caused by severe direct violence applied over the great trochanter, such as falls from a height, crushes between the buffers of a train, or run-over accidents. The fracture is therefore generally comminuted, and often impacted, the neck of the bone entering the upper part of the shaft. The great trochanter may in this way be completely separated from the rest of the shaft. Owing to the nature of the causative violence, this type is more common in young or middle-aged men. More rarely it may arise from indirect violence, as by falls upon the feet.

Symptoms.—In the common variety there will be well-marked signs of local trauma, the upper and outer part of the thigh will be much swollen, bruised, and tender. The great trochanter may be felt to be much thickened, and if there be no impaction crepitus may be obtained; the shortening of Morris's mid-trochanteric line may in these cases be definite. The deformity, and consequently the other signs, will be similar to those with a fracture of the neck. Shortening is, however, often more marked, and may even amount to 2 inches. If impaction be present, eversion may be less well defined, and here even movements of flexion may be performed, although much pain is caused. If due to indirect violence, the condition will more closely resemble a fracture of the neck.

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[1] *Trans. Roy. Med. Soc.*, December, 1908, Clin. Sect., p. 39.
[2] *Manual of Surgical Treatment*, part iii., 1905, p. 116.

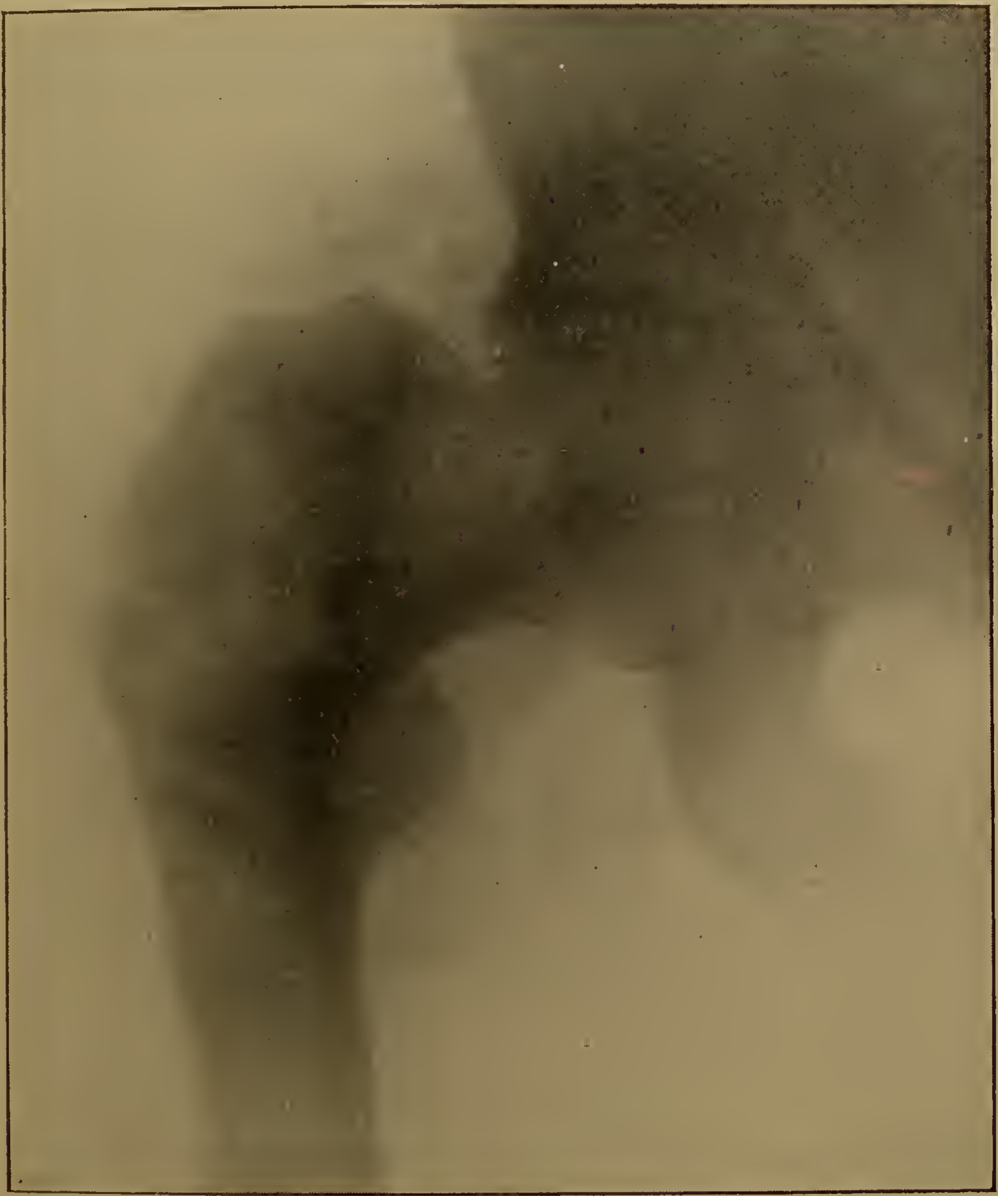

FIG. 70.—FRACTURE OF FEMUR THROUGH TROCHANTERS. (Mr. Openshaw's Case.)

Treatment.—In this type of patient the fear of lung complications will be less, and bony union is much more likely to occur. This is especially the case if the fracture be impacted. If the deformity be but slight it should not be disimpacted. At any time this is very difficult, and disimpaction may increase the resulting deformity, whilst the likelihood of bony union is considerably lessened. If, however, the deformity be great, attempts should be made to overcome it by extension and manipulation or, if these fail, by open operation. If unimpacted or after disimpaction, the affected limb should have an extension apparatus applied and be fixed in a Liston's long splint, care being taken that eversion is overcome and that there is no dropping of the foot (see p. 220). Extension should start with about 6 pounds weight, and be gradually increased. If extra heavy weight be required to overcome the shortening, a special apparatus (see p. 222) will have to be used, or the extension will slip. If the long splint unduly press upon the fractured trochanter, an interruption should be made in the wooden splint at this point, the two ends being fixed together by a strong rod of iron curved outwards away from the limb (Fig. 5, C).

This splint and extension should be maintained for six weeks. At the end of that time, if union be firm, it is removed, massage and passive movements being commenced, with the patient in bed, for another two weeks. A Thomas's hip splint is then applied, the patient being encouraged to walk with crutches, and a patten on the sound foot. Massage and passive movements must be continued until joint movements are free and the muscles healthy. The splint may generally be left off at the end of another month.

Instead of a Thomas's hip splint, a poroplastic apparatus or plaster of Paris mould is often fitted, as it also is in the case of fractures of the neck; but these should also be used in association with a patten on the sound foot and crutches, or shortening may result. The plaster mould is applied as follows: The patient's sacrum is placed on an Openshaw's rest, which consists of a smooth metal plate resting on four legs, from which it is easily lifted (Fig. 69, B). The plate is bound in between the patient and the plaster, and when this is completed the patient, together with the metal plate, is lifted off the legs. The plate is then easily slipped out from beneath the plaster. The leg and lower part of the trunk are wrapped in a sheet of cotton-wool, and the plaster bandages applied, as described on p. 27. They should form a hip spica, and should preferably reach from just above the knee-joint to 1 inch above the crest of the ilium, the band encircling the body being about 6 inches wide. Special care must be taken to make the portion over the groin and buttock strong. The edges are now finished off (p. 28), excess of plaster being removed with a scalpel, so that a wide opening is left for defæcation and micturition, and these edges finished off in the same way. The plaster is usually left in this condition, but by this means daily massage and passive movements are prohibited. This drawback may be easily overcome by cutting the plaster, while moist, down the whole length of its outer side, the inner side of the affected thigh, and the opposite side of the trunk, so that an anterior and posterior case are formed. These are bandaged into position until dry, when the two halves may be firmly held in position by bandages, and removed each day for massage. Such a casing is very useful, in that it is much less expensive for the patient.

Ewald[1] advises disimpaction in all cases where the prolonged after-treatment is not likely to be followed by hypostatic pneumonia and bedsores. He advises that disimpaction be brought about by powerful traction, with the leg in the fully abducted position, the patient being anæsthetized. Tilting of the pelvis at the same time may be prevented by fully abducting the other leg. Extension is then applied with both legs fully abducted, an abduction splint being required for this purpose. Care must be taken to overcome external rotation. The patient is after six weeks fitted with an apparatus, such as a plaster, which allows him to walk with the affected limb abducted. In young children this may be brought about by applying a high heel on the sound side, as this causes tilting of the pelvis, and hence abduction of the affected leg.

If the displacement be great and it cannot be overcome by extension, an open operation should be undertaken, and the fragments fixed together with pegs or screws. Even in this case the limb should be firmly immobilized for at least four weeks, and if shortening from bending of the screw beneath the muscular contraction tend to occur, extension should also be applied. At the end of that time after-treatment similar to the above should be commenced.

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[1] *Wien. Klin. Rundschau*, September 19, 1909, p. 597.

Separation of the Great Trochanter.—In some case direct violence may lead to separation of this trochante without the continuity of the shaft and neck of the bone being disturbed. If the fibrous aponeurosis be untorn, there will be but slight separation. In this case the limb should be fixed by a Liston's long splint o a Thomas's splint for four weeks to prevent the aponeurosis bein ruptured by muscular contractions but massage and gentle passive movements may be commence on about the tenth day. Usually however, this aponeurosis is ruptured, in which case it is alway advisable to fix the fragment b open operation, as not only i it difficult to control, but th aponeurosis will be turned in between the fragments and preven apposition. A curved incisio should be made, with its convexit downwards over the extremity c the shaft. The limbs of the incision may then be carried up a far as necessary to reach the separated fragment. This is draw down into position, and, the intervening aponeurosis bein removed, fixed either with a screw from above or by wiring

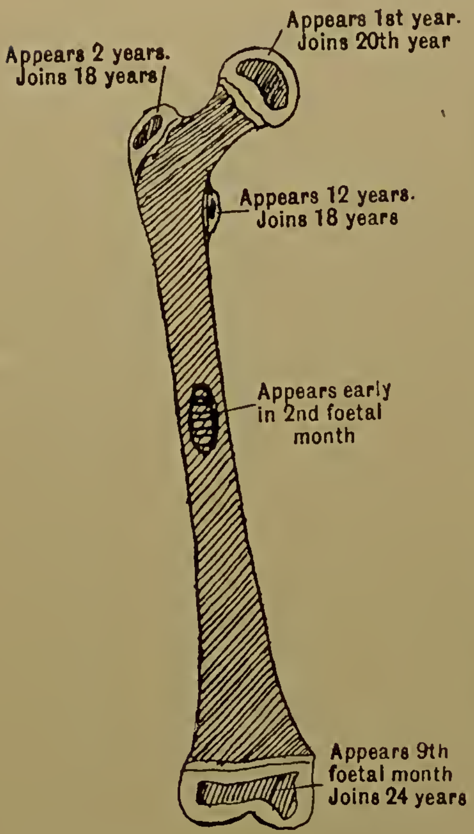

FIG. 71.—OSSIFICATION OF THE FEMUR.

Separation of the Upper Epiphysis.—The centre for th shaft appears in the second month of fœtal life, for the hea at the end of the first year, for the greater trochanter betwee the second and third years, and for the lesser trochant between the twelfth and thirteenth years (Fig. 71). Up the age of twelve to eighteen months, the cartilage for tl head and trochanter are joined, and thus a separation of tl whole of this area might take place; but such a conditio does not appear to have been recorded. The centre for tl head forms only that portion corresponding to the articul surface; it joins with the shaft at the eighteenth to the twentieth year. The great trochanter joins at the nineteenth year, and the lesser trochanter at the eighteenth.

The epiphysis for the head is the one most commonly separated (Fig. 72). It is caused by indirect violence, such as falls upon the feet. Most commonly the separation is partial, and such an accident is not infrequent. It is possible, as suggested by Keetley in 1888, and later as shown by Elmslie[1] and Sargent and Kisch,[2] that this is the usual cause of adolescent coxa vara. In some cases a slight

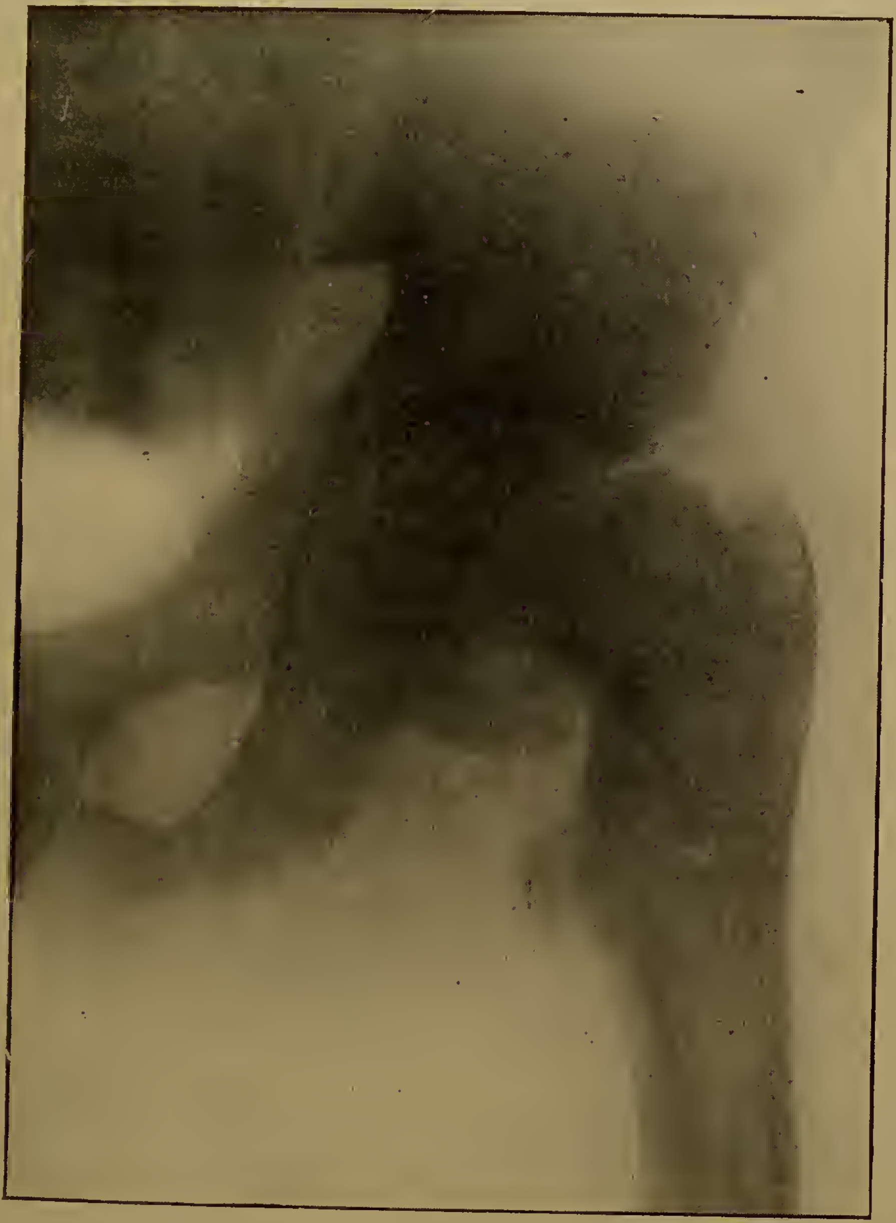

FIG. 72.—SEPARATION OF EPIPHYSIS OF HEAD OF FEMUR. (Mr. Fenwick's Case.)

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[1] *Lancet*, February 16, 1907.

[2] *Ibid.*, July 6, 1907, p. 14.

separation of this nature, the so-called "paraepiphyseal strain of Ollier," may be the localizing cause of acute epiphysitis. The patient will complain of pain on walking, and will limp; the affected leg will be shortened, everted, and adducted; and the great trochanter will be prominent and above Nélaton's line. The condition will be made manifest by a radiograph. Much more rarely separation is complete, when the leg will not only be shortened and everted, but soft crepitus may be obtained.

Treatment.—If there be but partial separation—*i.e.*, a condition of traumatic coxa vara—the patient is placed in bed, and an extension apparatus applied, with the leg in a position of abduction, the foot of the bed being raised. This is best done by the use of Openshaw's abduction box splint (see Fig. 73), which is applied in a similar manner to an ordinary box splint (p. 222), the affected leg being then gradually abducted. Eversion of the foot is at the same time guarded against. This splint should be kept on until deformity is overcome, sufficient weight being applied for this purpose. It will usually require two to three months, after which the patient is made to wear a Thomas's hip splint until union is firm, as shown by the absence of all pain. Even by this method some shortening is likely to result.

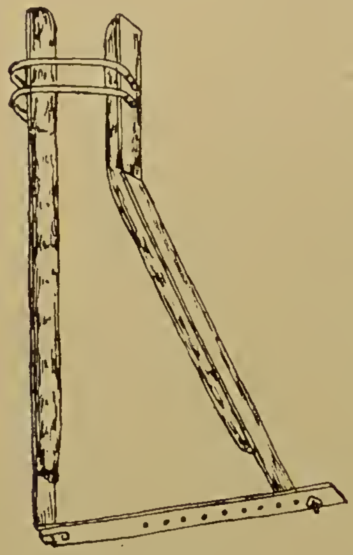

FIG. 73.—OPENSHAW'S SINGLE ABDUCTION SPLINT.

If the epiphysis be completely separated, the treatment will largely depend upon its position. A radiograph should always be taken, and if there be but little separation, treatment will be carried out on similar lines to that for a partial separation, the blood-supply of the epiphysis along the round ligament being probably sufficient to maintain its vitality, and union may thus occur. If, however, the displacement be great, and attempts at reduction fail, an open operation should be undertaken, the joint being exposed by the anterior incision. Attempts to unite the epiphysis may be made, but will probably fail, in which case it is generally best to excise it. Such cases are, however, very rare. Separation of the epiphysis of the great trochanter is extremely rare. It is due to direct violence. In spite of the powerful muscles attached to it, separation from their contraction does not seem to occur. The aponeurosis is rarely torn, so that much separation is unusual.

There may therefore be only tenderness, and perhaps a slight give on pressure, whilst radiography will show an apparent increase of the epiphyseal line.

Treatment will be similar to that for separation of the great trochanter.

Separation of the lesser trochanter is very rare. J. Hutchinson[1] was only able to find one undoubted case, in which the diagnosis was proved by a post-mortem examination, the patient dying of pyæmia. It was due to excessive contraction of the ilio-psoas muscle, due to a fall on the feet whilst trying to leap a fence. The condition could probably only be diagnosed in life with the aid of a radiograph, and would require open operation, with attempts to screw the fragment in position.

The Shaft.

Fractures of the shaft are more common in the young or middle-aged. They may occur in different situations, each of which shows different displacements; but it must be remembered that there is no hard-and-fast line of separation between the different varieties, and hence combined deformities may be present, and it must be the aim of the surgeon to treat the deformity, rather than to expect good results from a hard-and-fast line of treatment used for fractures in certain positions.

They may be caused by direct violence, when they are more commonly transverse, or by indirect violence, when they are usually oblique.

Of the Upper Third [3].—Fractures in this position are usually caused by indirect violence, such as blows or falls upon the lower portion of the shaft. The line of fracture is transverse or oblique. The upper fragment is flexed by the action of the ilio-psoas, and abducted by the action of the glutei attached to the great trochanter (Fig. 74). The lower fragment is drawn inwards in its upper part by the action of the adductors, and upwards by the hamstrings and quadriceps, so that considerable shortening is produced. It is also much everted by the weight of the limb.

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[1] *Brit. Med. Journ.*, July 16, 1887.

Symptoms.—There will be complete loss of use in the affected limb, the patient being unable to walk. Movements of the lower fragment are ill-controlled, and are associated with much pain. The injured leg is shortened and everted, while tenderness and some swelling are present at the site of fracture. In some cases the projecting upper fragment will press upon, and may occlude or perforate, the femoral vessels, in which case there will be severe interstitial hæmorrhage, and gangrene may result. There is increased mobility at the site of fracture, accompanied by pain and crepitus.

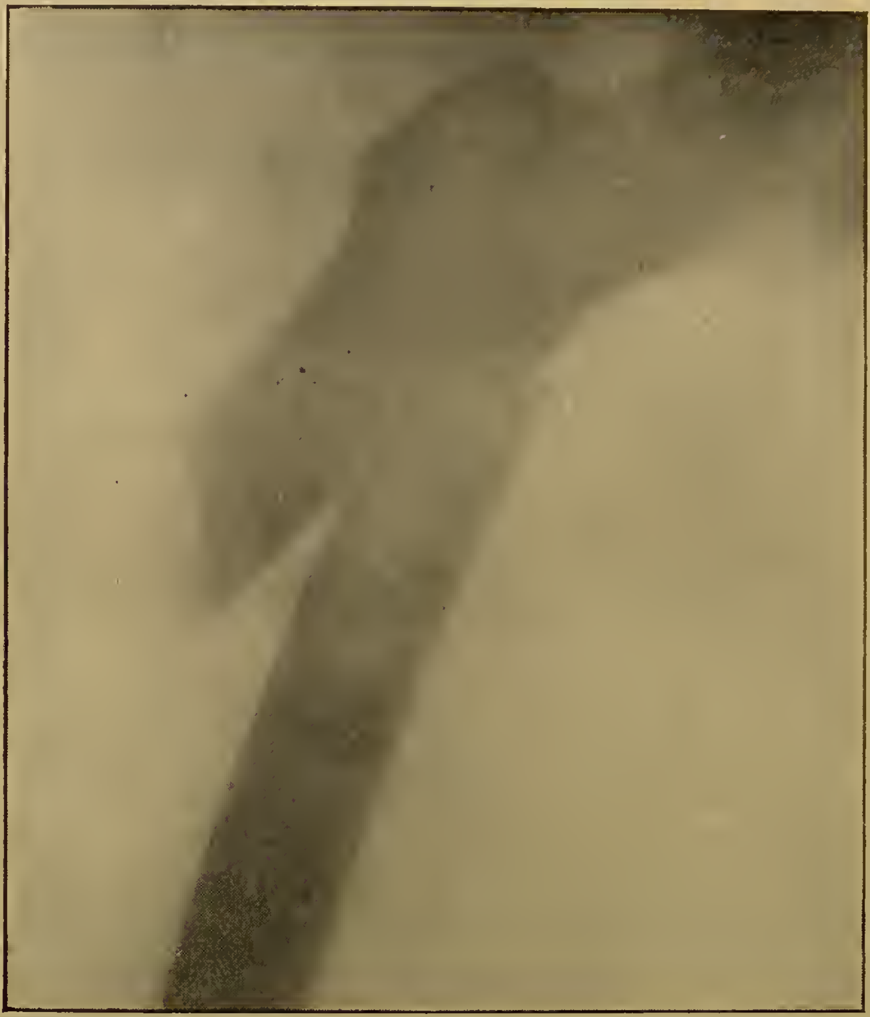

FIG. 74.—FRACTURE OF UPPER THIRD OF SHAFT OF FEMUR, SHOWING EXAGGERATED ABDUCTION OF UPPER FRAGMENT. (Mr. Eve's Case.)

Treatment.—The upper fragment, being very short, cannot be adequately controlled, and if pressure be applied over it, in order to overcome the flexion, injury to the vessels is very likely to be caused. For this reason the lower fragment must be brought up into line with the upper, extension being applied at the same time in order to overcome the shortening. This may be best accomplished by the use of a Hodgen's splint. This consists of a wire frame shaped as in Fig. 75. It is applied as follows: An extension apparatus is fixed to the leg (p. 21). Strips of flannel 3 inches wide are now fastened by stitches or safety-pins to one side of the splint. This is placed over the leg, and the strips passed under it and fastened to the opposite side of the splint, so that the limb rests in a flannel sling suspended from the sides of the splint. A short piece of cord is now passed through the stirrup, and firmly knotted to the end of the splint, which is now raised by the ropes and pulleys until sufficiently flexed to lie in line with the upper fragment. The upper cross-bar of the splint should lie along Poupart's ligament, but should not press upon it. The action of the splint is as follows: The pull of the rope acts along the line AB, and may be resolved into

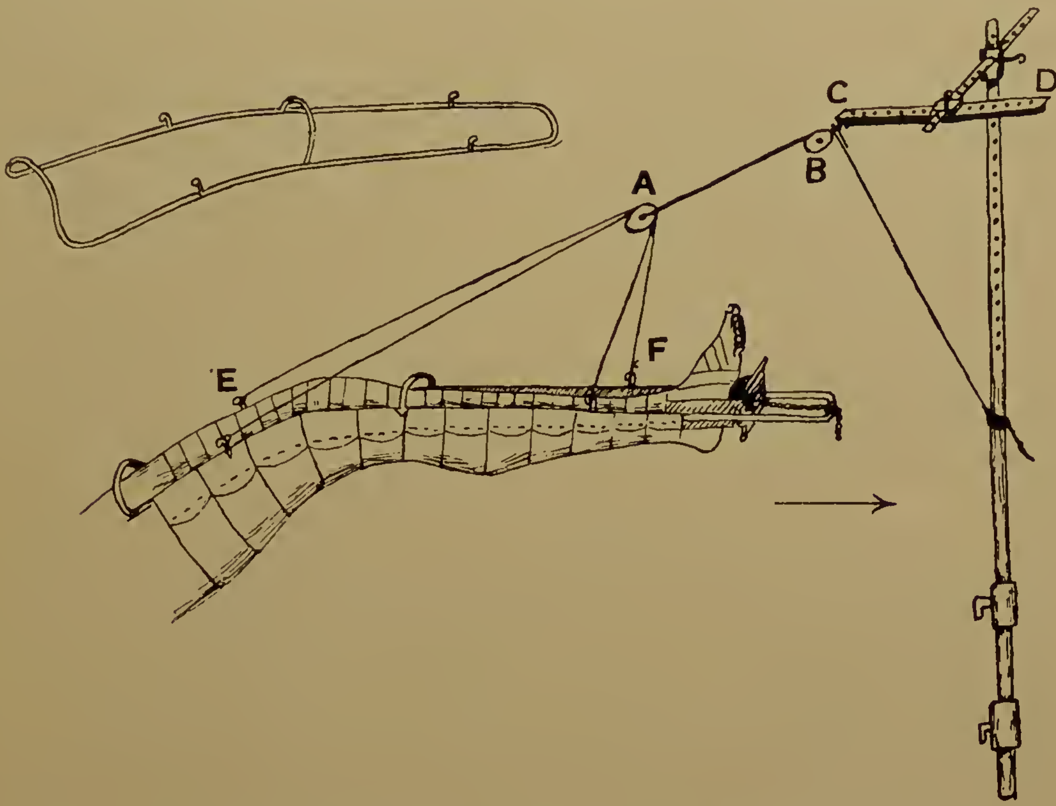

FIG. 75.—HODGEN'S SPLINT—LOOSE AND APPLIED.

two factors: a vertical one, causing flexion of the leg, and a horizontal one, tending to pull the splint off the leg in the direction of the arrow. This is prevented by the cord passing from the stirrup to the end of the splint, so that, instead of the splint being pulled off, the whole lower fragment is extended, and thus the extension is adequate only when this cord is quite tight.

If the upper fragment be greatly flexed, the pulley should be placed in the position C, for then the pull of the cord is mainly upwards, and thus the lower fragment is more completely flexed. If, on the other hand, the deformity is mainly one of overlapping, the pulley should be placed at D, the pull of the cord being then chiefly horizontal, and thus the downward extension is more marked. The splint should be sufficiently elevated to just lift the buttock on the affected side off the bed, so that active counter-extension of the upper fragment is obtained.

The splint may be adjusted to always lie in the line of the leg by shortening or lengthening the cords AE or AF. If the leg be flexed, the cords AF will have to be shortened, and those marked AE lengthened; whilst if the limb be more nearly horizontal, the opposite adjustment must be carried out.

Eversion or inversion may be readily overcome by the following simple manœuvre. If there be eversion, as is so commonly the case, the two outer cords are shortened, so that the splint is tilted inwards, and thus the foot and leg are also inverted.

The limb should also be abducted so that the lower fragment comes into line with the upper. This is brought about by having the bar CD sufficiently far to the outer side of the limb. The position of this bar can be altered, as is shown in the figure.

This splint is extremely satisfactory if properly applied, and is very comfortable for the patient, who can partly sit up in bed without disturbing the fragments, while massage can be applied to the upper part of the thigh after the first few days.

As will be seen from the above description, the addition of weights to the metal frame, as is sometimes advised, is a poor method of increasing the extension. These weights will certainly tend to swing downwards until vertically beneath the pulley, but they act at a great mechanical disadvantage, and should therefore not be used. If the end of the splint project beyond the line of the pulley, they will decrease and not increase the extension. Increase of the extension is much more simply brought about by moving the pulley in the direction D. If there be both overlapping and flexion of the upper fragment, the pulley is placed at D, and the cross-bar raised to its fullest height.

The splint should be kept in position for six weeks. At the end of this time, if union be firm, the patient may be allowed to walk in a Thomas's hip splint if it be desired to keep all weight off the leg; but if it be thought preferable to allow some weight to be borne upon it, the limb should be strengthened by the application of a poroplastic or plaster of Paris splint, applied as in the case of a fracture through the trochanters. The latter will be most satisfactory if divided, when massage and passive movements can be given every day until the normal function of the limb is restored. Either apparatus will probably have to be worn for a month.

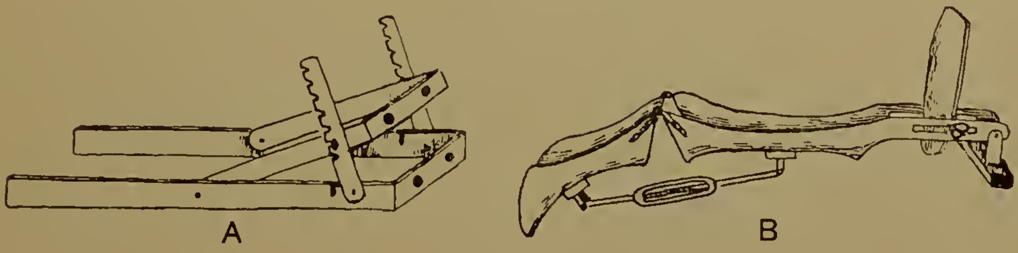

FIG. 76.

A, Double box splint for applying extension to the flexed thigh; B, MacIntyre's splint.

In young children Hodgen's splint is unsatisfactory, as they do not lie sufficiently quiet. In them it is usual to support the limb on an inclined plane and apply extension. The child, however, soon turns over on to its side, so that the fragments are not maintained in position, and the benefit of the inclined plane is lost.

For this type of case I have had the following splint made, and find that it gives very good results. To an ordinary box splint is fitted a second box which works on a hinge at the level of the hip-joint, and is supported by pegs on a racket at a varying angle (Fig. 76, A). It is applied as a box splint, but both legs are bandaged to the inner box, which is then flexed to the degree required to overcome the deformity.

If desired, the affected limb alone can be flexed, the other being bandaged to the outer box, but it is more comfortable with both legs flexed.

It is maintained in position for four to five weeks. At the end of that time, if union be good, a plaster casing is applied. In young children this should not be divided, as better fixation is obtained with a solid casing, and ankylosis or stiffness is rare in children even after prolonged fixation, and without any massage or passive movement.

In some cases where deformity is very great and cannot be overcome by the above methods, or where there is malunion, operative treatment will be required. A free incision should be made down to the site of the fracture, one on the outer surface of the thigh being usually most convenient. The fragments of the bone are now freed from aponeurosis, muscle fibre, or blood-clot, in recent cases, or from callus in older cases.

In older cases of malunion the junction will have to be divided. The ends of the bone are now brought into good apposition by continued extension on the leg and manipulation of the fractured ends.

Fixation will generally be best accomplished by two long perforated plates, which are securely screwed into each end of the bone, the wound being closed without drainage. The limb is supported either in a Liston's long splint or a Thomas's splint in the case of an adult, or in a box splint in the case of a child. On the tenth day the stitches are removed and massage commenced, passive movements being cautiously added at the end of two weeks. At the end of four weeks the patient may be allowed to walk in a Thomas's splint, so that no weight is borne on the affected limb. The use of this splint may be gradually discarded at the end of six to eight weeks. Massage and passive movements must be continued until all movements are free.

Of the Middle Third [4].—Fractures of this portion of the shaft are caused by direct violence, such as kicks or blows upon the front of the thigh, when they are more likely to be transverse, and may be comminuted. They may also be caused by indirect violence from falls or blows upon the leg at a lower level. In this case they are generally oblique, the line of fracture usually running from above downwards and forwards (Fig. 77). In either case the upper fragment is generally of such a length that the ilio-psoas muscle will

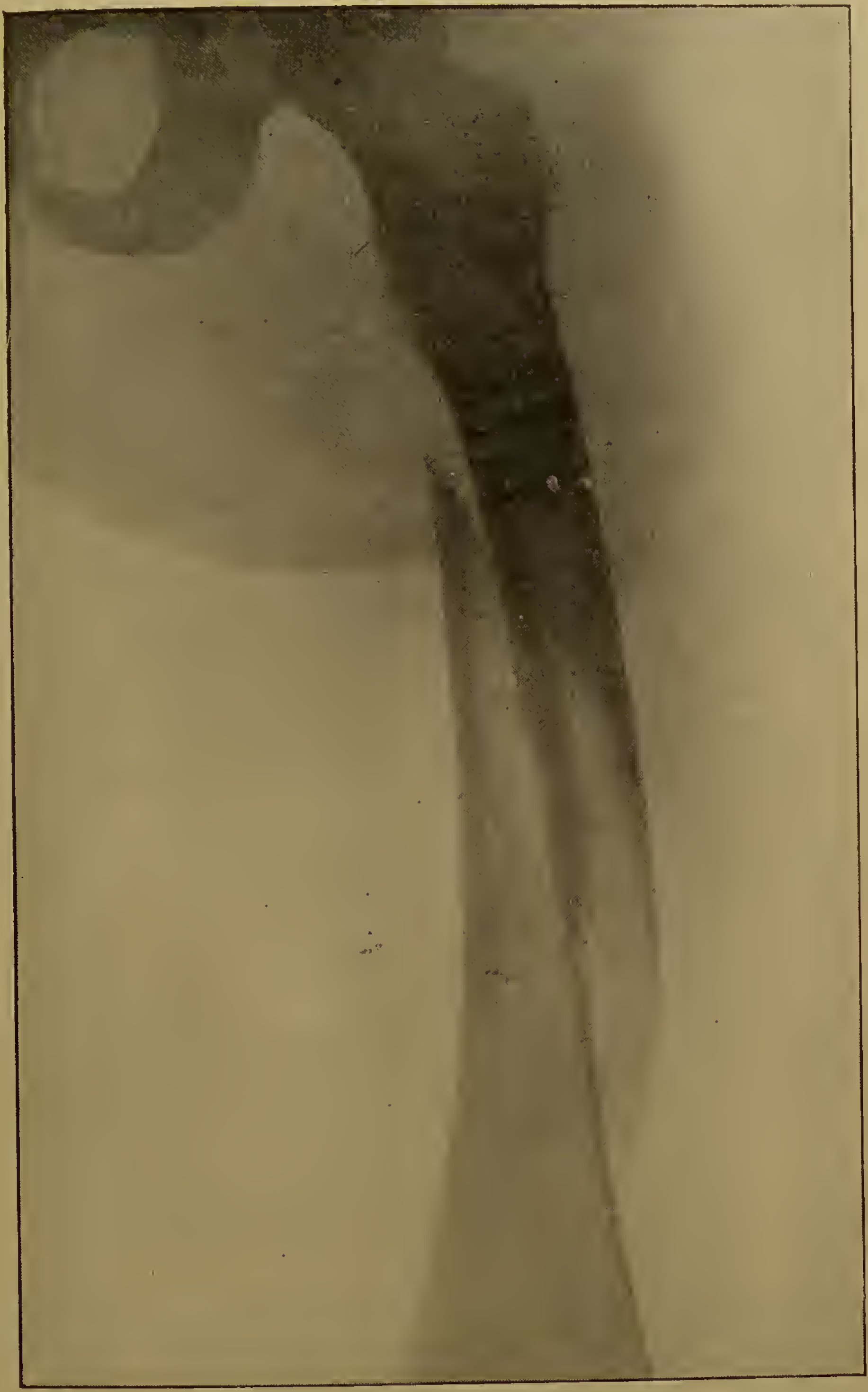

FIG. 77.—OBLIQUE FRACTURE OF SHAFT OF FEMUR.
(Mr. Rigby's Case.)

have but little power of flexing it, or the glutei of abducting it. The deformity is therefore mainly one of shortening, but this, owing to the powerful action of the long muscles of the thigh, may be extreme, not uncommonly amounting to two or three inches. If oblique, one or other sharp-pointed end may then perforate the muscle, especially the crureus, whereby the fragments are separated and reposition by manipulation becomes impossible.

Symptoms.—There will be a history of severe or slight trauma, according to whether direct or indirect violence is the causative factor. The limb will be painful, and much bruising and swelling may be present. The patient will be unable to walk, and will have lost all use of the affected leg. Abnormal mobility of the lower fragment, associated with increased pain and crepitus, will be obtained. The leg will be shortened, and in some cases the displacement of the fragments may be sufficiently great to be palpable through the soft tissues of the thigh. The lower fragment will here also tend to be everted, owing to the weight of the leg. A skiagram should be taken to show the amount of displacement.

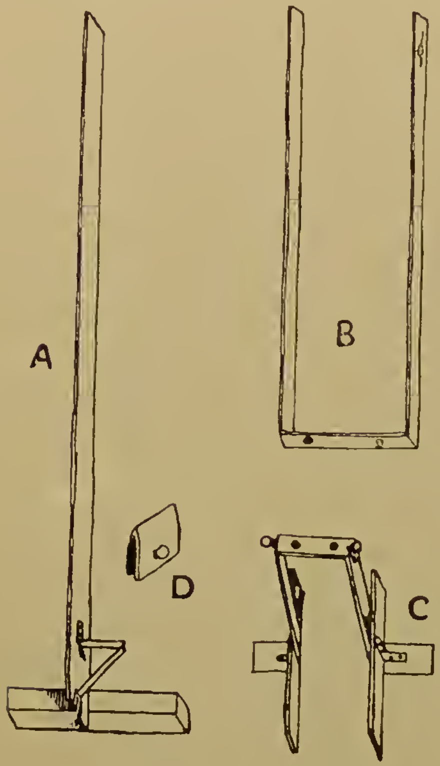

FIG. 78.
A, Modified long Liston's splint; B, box splint; C, Bryant's gallows splint; D, Openshaw's clip.

In young infants a fracture of the femur may occur, generally during attempts to bring down the leg in an incomplete breech presentation. Most commonly the line of fracture is transverse, and is situated in the neighbourhood of the middle of the shaft.

Treatment.—In this case the main difficulty to be overcome is that of shortening. For this purpose an anæsthetic should be given, and firm extension applied to the leg by an assistant whilst the fragments are as far as possible manipulated into position. They must now be fixed, and continuous extension applied to overcome muscular contraction. An extension apparatus (p. 21) having been applied from just above the ankle to halfway up the thigh, a Liston's long splint is fixed in position. This consists (Fig. 78, A) of a long strip of wood about 3½ inches wide, and long enough to reach from the axilla to 12 inches beyond the patient's foot. At its lower end is a thick-weighted cross-bar of wood, which prevents rotation. The whole of the splint, with the exception of the lower 9 inches, is carefully padded. It is placed on the outer side of the patient's trunk and affected leg, a long strip of Gamgee tissue, well powdered with boric acid, being applied between the padding and the patient's skin. A further pad of the same material is placed between the end of the splint and the axilla. A domette bandage, 2½ inches wide, is taken, and two or three fixation turns made round the ankle, the bandage passing on the extensor surface from without inwards, and with the inner side of the bandage next to the skin. When fixed by these turns the bandage is brought up between the splint and the leg, then over the splint, so that the ankle is supported as in a sling.

When the bandage is applied round both leg and splint together, it will be passing in the correct direction—*i.e.*, from within outwards (Fig. 79). The whole leg up to the groin is bandaged to the splint, and the trunk bandaged to the upper part with a rib roller of flannel.

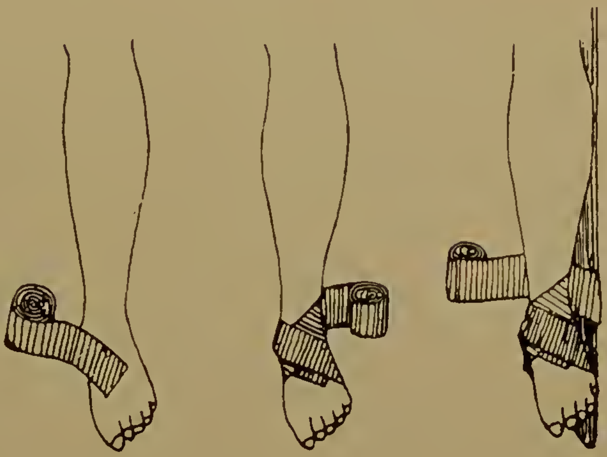

FIG. 79.—METHOD OF BANDAGING LOWER LIMB TO AN EXTERNAL SPLINT.

All padding is omitted for the sake of clearness.

Next day the weight is applied to the stirrup. This should begin with about 6 or 7 pounds, and may be increased to 12 pounds, the chain or cord supporting the weight passing over a pulley fixed to the foot of the bed. When the extension is acting, the leg is alone pulled down, the bandage, enveloping the leg and splint, having sufficient give in it to allow this; so that if the cross-bar at the end of the splint rest against the foot of the bed, extension will still be active, and it will be unnecessary to elevate the foot of the bed, for the trunk will be prevented from being also pulled down by its fixation to the splint by the rib roller, and by the pressure of the end of the splint in the axilla. The splint should be worn for six weeks.

In some cases a weight of 14 pounds is insufficient to overcome the shortening, and may then be increased even to 28 pounds, but if the above method be used the extension apparatus will give with this weight.

The following method introduced by Mr. Openshaw may here be adopted. The stirrup is brought down into close apposition with the metal bar at the end of the Liston's splint, and the two fixed together by a Λ-shaped metal clip (Fig. 78, D). The chain or cord to which the weight is attached passes through this clip and is knotted. When extension is applied, both leg and splint will be pulled upon, and the extension apparatus will be less likely to give, as it is reinforced by the bandage passing round both leg and splint. The padding on the splint is, however, likely to slip; to overcome this the edges of the splint are notched, and thus the padding more firmly secured. By this method very great shortening may be overcome, and if the weight be increased gradually no pain is caused.

If the upper fragment be flexed, the fracture should be treated as one of the upper third, and a Hodgen's splint used. As already pointed out, extension without a splint has been used for these cases.

In young children a single long splint as above will be insufficient to control the patient. For them a box splint (Fig. 78, B) should be applied. An extension apparatus is fixed to the affected leg in the usual way, and the child is now placed in the box, and each leg bandaged to the sides, in a manner similar to that used with a Liston's splint. In bandaging the chest and trunk both sides of the splint are included. The sides of the splint should be sufficiently long to reach from the axilla to at least 6 inches below the feet, so that the stirrup on the affected limb is 2 to 3 inches above the cross-bar of the splint, and thus extension is not interfered with. Each side is well padded from the axilla to below the foot, the padding being covered with mackintosh for a distance of about 18 inches opposite the pelvis. The bandages may in their upper part also be protected as follows: A piece of mackintosh a foot square is taken, and made to enwrap the inner side of the upper part of each thigh, the mackintosh surface being next to the patient's skin. The lower half of it is fixed by the turns of the bandage; the upper half is then turned downwards, and so covers and protects the upper part of the bandages on the inner side of the thigh. Powdered strips of Gamgee tissue are inserted between the patient's skin and the splint as with a Liston's splint, and any other points of pressure, such as the axillæ, are similarly protected.

In very young infants the method known as "Bryant's method" may be used. A small stirrup is applied to each leg, care being taken that the strapping is very evenly applied, lest the delicate skin be injured. Each leg is now suspended from a gallows splint (Fig. 78, C), which should be of such a height that the buttocks are just clear of the bed. The weight of the body thus acts as the extension. This splint is, however, uncomfortable, and presents difficulties in the nursing of such small children; while simple bandaging of the flexed limb to the abdomen, as is sometimes done, gives but poor results. To overcome these difficulties, R. Jones[1] advises the following method: A small Thomas's knee splint is applied, the upper ring of which, well padded, is pressed up against the pubes and tuber ischii. Extension plasters are fixed round the ankle, and by tying these to the lower cross-bar of the splint effective extension is applied, and the child can be easily nursed and carried about.

In an adult the Liston's long splint is kept in position for six weeks. If at the end of that time union is firm, it is preferable to keep the patient in bed for a week with no splint, while massage and passive movements are applied. After this a Thomas's hip splint or divided plaster is fitted, and worn for another month, massage and passive movements being continued, and the patient allowed to walk with the aid of crutches.

In younger children the box splint is maintained for four to five weeks, a simple plaster being then applied for three further weeks. This cannot be removed by the parents, and in young children stiffness after plaster is very unusual.

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[1] *Brit. Med. Journ.*, June 6, 1908.

In infants the gallows splint or Thomas's knee splint is removed after three to four weeks, no further treatment being then required.

If the deformity be great or if the above methods fail to reduce it, as shown by radiography, or in cases of malunion or non-union, an open operation should always be performed. Failure of reduction in the recent cases will probably be due to perforation of the muscle by one of the fragments.

A free incision is made in the case of a transverse fracture, preferably on the outer side of the leg, and if oblique down on to the position in which the screws would be inserted. All intervening tissue is removed, the fractured surfaces freshened if necessary, or, if united by callus in an abnormal position, freely separated. The ends are now brought into accurate apposition by a combination of extension and manipulation. In the case of transverse fractures, fixation is best brought about by the use of plates firmly screwed into either fragment; if oblique, screws alone may be used. The wound is now closed and the limb immobilized by a Liston's long splint. An the end of two weeks this may be removed for daily massage and very gentle passive movements, but is replaced until the end of four to five weeks, when the patient may be allowed to get about with a Thomas's knee splint and crutches, no weight being borne on the leg for another two to three weeks. During this time massage and passive movements are continued. The patient is then encouraged to gradually use and bear weight on his leg until the normal functions are regained. To aid the application of early passive movement, Chapple[1] recommends the use of a modified double Thomas's splint, with a hinged kneepiece, allowing free movement on the affected side.

If the case has been one of non-union, recovery will be very much slower, and no use should be made of the limb until there is evidence that union has progressed favourably.

Of the Lower Third [5].—Fracture in this position, usually known as "supracondylar fracture," is produced most commonly by direct violence; but it may be caused by falls upon the knee, in which case the line of separation is rather more oblique, running from in front upwards and backwards. It is situated generally between 3 and 4 inches above the knee-joint (Fig. 80). The lower fragment, partly from the direction of the violence, but more especially owing to the action of the popliteus and gastrocnemius, is rotated backwards, so that its upper end projects out behind, and in this position may press upon and occlude or lacerate the popliteal artery or vein, or even perforate the skin. The upper end is drawn

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[1] *Practitioner*, February, 1910, p. 257.

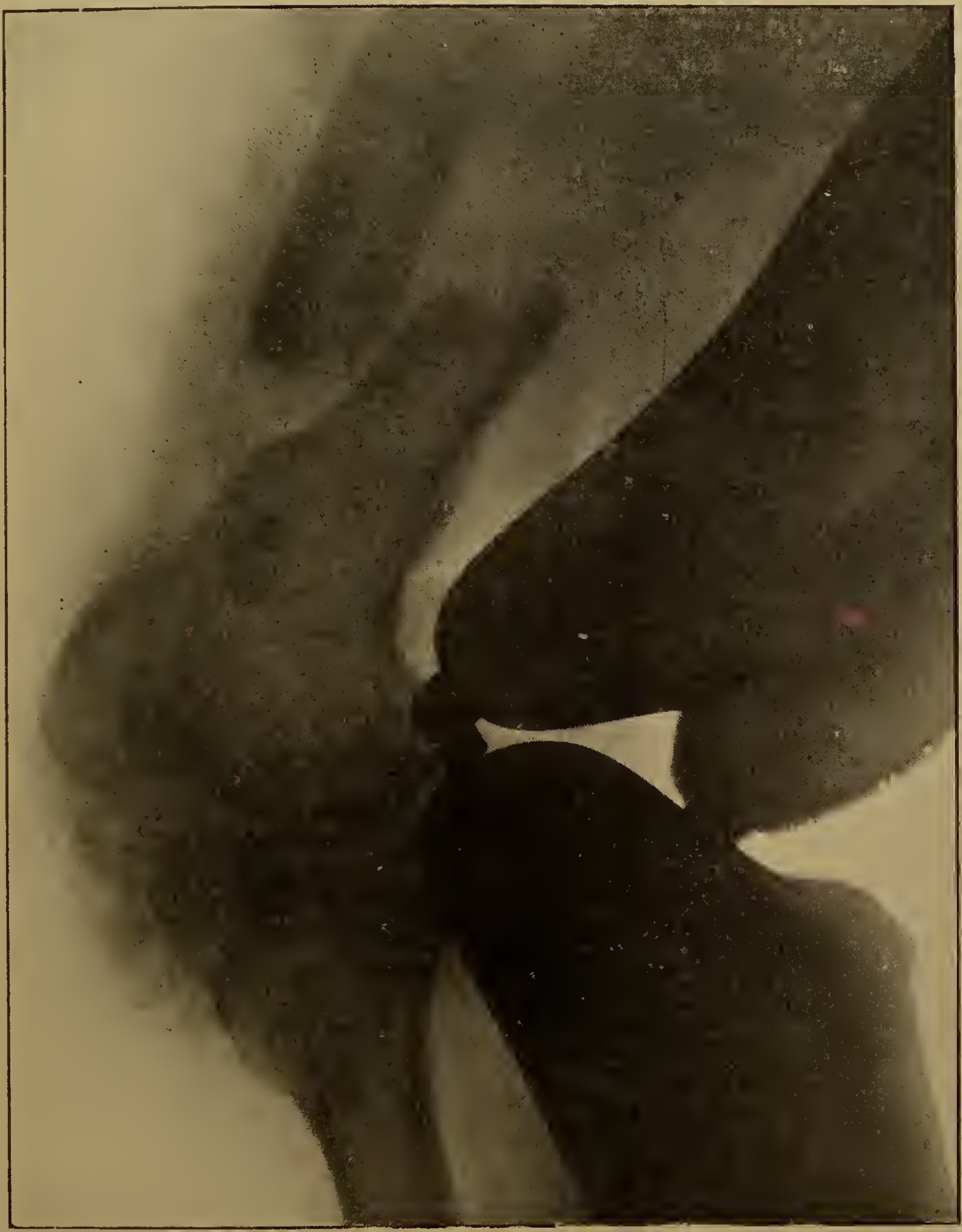

FIG. 80.—FRACTURE OF LOWER THIRD OF SHAFT OF FEMUR: LOWER FRAGMENT ROTATED BACKWARDS AND DRAWN UPWARDS. (Mr. Dean's Case.)

downwards by the action of the quadriceps and hamstrings, and may, especially if the fracture be oblique, perforate the former or enter the knee-joint.

Symptoms.—There will be loss of function in the part; the lower end of the thigh will be swollen and painful, abnormal mobility, and perhaps crepitus, being obtained. If the popliteal vessels are pressed upon, the part will be cold, and there will be absence of pulsation in the tibial vessels; whilst if they be perforated there will be extensive brawny swelling around the knee, most marked in the popliteal region, and spreading down the leg, while all pulsation will be absent. In a short while extensive staining from the presence of the extravasated blood will make its appearance.

Perforation of the knee-joint will be associated with effusion into that structure. The leg will be flexed at the knee and shortened. The prominences of the upper end of the lower fragment and the lower end of the upper fragment will be palpable, and may be visible.

Treatment.— In simple cases the patient must be anæsthetized, so as to overcome all muscular spasm. The knee is then fully flexed, and extension applied to the upper end of the tibia while this full flexion is maintained. This is best accomplished as follows: The leg being placed on its outer side, an assistant fully flexes the knee, and keeps it in this position by pressure upon the foot. The surgeon now passes both hands round the calf of the leg, as high up as possible, and pulls firmly in the direction of the long axis of the femur. By this means the deformity is usually easily overcome, but tends to recur. It is generally advised that the leg be put up in a flexed Macintyre's splint (Fig. 76, B), or in a Hodgen's splint with extension; but by these means it is impossible to obtain sufficient flexion, and the deformity is almost certain to recur. The leg should be placed on its outer side, with the knee fully flexed, after the method advised by J. Hutchinson and Barnard[1] in cases of separation of the lower epiphysis. In this position the tendency to recurrence is overcome. The leg may be maintained fully flexed by a band round the upper part of the thigh, from which passes a strap to a second band round the ankle.

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[1] *Lancet*, May 13, 1899.

In this position massage may be commenced in a few days. The knee should be kept flexed for four weeks, at the end of which time gentle passive movements may be begun, the knee afterwards being replaced in its flexed position. Full extension should not be allowed until the end of six weeks, when the patient may be permitted gradually to get about, the leg being supported by a divided plaster for another two to three weeks, massage and passive movements being continued daily.

If it be impossible to overcome the deformity by this method, as may occur when the upper fragment has perforated the crureus or the knee-joint, an open operation should be undertaken early, before adhesions have had time to form.

A free incision should be made on the outer side of the femur, the knee-joint being avoided if possible. The fragments are manipulated into position, the leg being flexed at the knee to assist this. They are then firmly fixed with plates and screws, and the wound closed. The after-treatment should be similar to that for simple cases, passive movements being begun at the end of two weeks. If the knee-joint be perforated, it should be opened at the same operation, and all clot cleared out, the joint being then closed with catgut sutures.

If the vessels are lacerated, a vertical incision should be made over them in the popliteal space, and all blood-clot removed. Wherever possible the openings in the vessels should be sutured, or an end-to-end anastomosis made (see p. 54), ligature of both these vessels introducing a severe danger of subsequent gangrene.

If compound, great care must be taken to render the wound as aseptic as possible, for if extensive suppuration occur, amputation may be necessary.

THE LOWER EXTREMITY.

Fractures in this position are generally due to severe direct violence, and are thus often complex. Not only is the joint involved by the fracture, but ligaments may be torn, and thus much displacement occur. The following varieties are recognized:

T- or Y-shaped Fractures [6].—These correspond in nature to the similar type of fracture occurring at the lower end of the humerus. They are most commonly caused by severe direct violence to the lower end of the femur, such as by kicks from a horse, crushes, or the fall of heavy weights upon the knee, and may therefore not uncommonly be compound. In other cases they may arise from falls from a height upon the feet, the tibia being driven upwards like a wedge, and partly separating the two condyles of the femur. In either case the vertical line of fracture passes generally between the two condyles, entering the joint close to the attachments of the crucial ligaments, the transverse portion lying just above the condyles, and therefore considerably lower than in the supracondyloid type. The two condyles are driven upwards by the force of the blow, and are often widely separated. If compound, the wound is almost certain to become infected.

Symptoms.—The functions of the leg are completely disorganized, the joint will be swollen and painful, whilst above it the femur is felt much widened, with a prominence on either side, ending sharply above and corresponding to the displaced condyle. Abnormal mobility, especially to lateral movements of the leg, and crepitus, will be obtained. If the crucial or other ligaments are also ruptured, this mobility will be increased. The leg as a whole will be shortened, the lower portion being everted and somewhat flexed. A radiograph should always be taken, for not only can this method alone show the amount of injury to the femur, with the extent of displacement, but accompanying fractures of the upper end of the tibia may without it be overlooked.

Treatment.—Attempts to overcome deformity by manipulation and splintage alone are almost certain to fail, for here, as when other joints are involved, absolute reposition is required in order to give good functional results. Moreover, if these attempts be continued for any length of time, reduction by operative methods will become increasingly difficult. For these reasons it will nearly always be best to decide upon an early operation. Manipulation under an anæsthetic, with subsequent fixation on a Macintyre's splint, may be tried, but if by the end of three or four days the position of the fragments, as shown by radiography, is not very nearly perfect, operative treatment should then be undertaken. A lateral incision on either side of the joint will generally be found most convenient. The joint cavity is opened and all blood-clot gently swabbed out. Extension upon the upper end of the tibia, with the knee in the semiflexed position, is then made by an assistant, and the fragments manipulated into position. The surgeon should not rest satisfied until the irregularity on the joint surface at the line of fracture is almost imperceptible. The two lower fragments, being firmly held, are now drilled from side to side, and fixed by a long screw passing through them both. This solid fragment is now brought into accurate apposition with the lower end of the shaft, and firmly united to it with metal plates and short screws, or by means of long screws passed obliquely through the shaft and fragment. The joint cavity is now carefully examined, and, if either of the crucial or other ligaments are ruptured, attempts made to suture the ends together, fine kangaroo tendon being the most useful substance for this purpose. The wounds are now closed without drainage. The leg may be placed upon a Macintyre's splint in a somewhat flexed position, or preferably laid upon its outer side and firmly bandaged to a well-padded external angular splint, reaching from the ankle nearly to the groin. The benefit of this type of splint is that it can be unfastened without disturbing the fracture, so that passive movements, without which adhesions in the joint are almost certain to occur, may be commenced in three or four days. Lateral movements, which are likely to disturb the fragments, must be carefully guarded against. On the tenth day the stitches are removed and gentle massage commenced. After four weeks the splint may be removed, the patient being kept in bed, and massage and passive movements persevered with, until about the end of eight weeks, after which he may be gradually allowed to walk, the limb being supported in a divided plaster, which is removed each day for movements. This plaster should not be worn for more than an extra month, if possible, but movements and massage may be required for a long time.

If compound, the wound should be thoroughly cleansed at once, and the fragments fixed as above. A small tube should be left in, and removed, if there be no infection, at the end of forty-eight hours. The results are, however, frequently bad, as sepsis is almost certain to occur, and free drainage, with consequent ankylosis, will then result. Under these circumstances the surgeon should aim at keeping the leg straight, so that the limb, although ankylosed at the knee, may be useful.

Separation of Either Condyle.—Either the internal or external condyle may be separated by a similar type of trauma as in the last variety, but of less severity. The line of fracture is oblique, and enters the joint between the two condyles. In either case the separated condyle is pushed upwards by the tibia, so that a traumatic genu-valgum or genu-varum results. The fracture may be accompanied by a rupture of the lateral ligament upon the opposite side of the joint, or by a fracture of the upper end of the tibia.

Symptoms.—The affected knee-joint will be much swollen from the effusion of blood and serous fluid. The leg will be displaced outwards or inwards, the former condition often being associated with a traumatic outward displacement of the patella, which is easily replaced, but springs outwards immediately. Lateral movement of the joint is increased, this movement causing increased pain and crepitus. The displaced condyle may be felt, with a sharp upper edge, and movement of it obtained. Often, however, the swelling is so great that this cannot be accurately determined.

Treatment.—Reposition may be attempted under an anæsthetic, and is generally made easier by fully flexing the knee. In some cases, where there is much lateral displacement, the deformity may be well overcome by applying a straight external splint when there is genu-valgum, and an internal splint when there is genu-varum, the deformity being overcome by firmly bandaging the well-padded knee to the splint. In other cases better results are obtained by putting up the knee in a position of full flexion. Whichever plan be adopted, a radiograph should be taken after a few days; and if the position be not good, an open operation should be decided upon—otherwise loss of function of the joint will result.

An incision is made over the affected condyle, the joint opened and cleared of blood-clot, the fragment brought into apposition and fixed with a screw. The after-treatment will be on the same lines as in the last case.

Separation of the Lower Epiphysis.—The centre for the epiphysis appears at the ninth month of fœtal life. The epiphysis includes the whole articular surface, but so extensive is the synovial membrane, and so firmly attached, that, according to J. Hutchinson junior,[1] it is always injured. The epiphysis unites with the shaft at an age varying from the twentieth to the twenty-fourth year (Fig. 71). Although uncommon, separation of this epiphysis is an extremely important injury to the lower end of the femur. It may be caused by violent over-extension of the knee-joint, or by blows upon the shaft of the femur just above the epiphysis, or by the leg being caught in the spokes of a wheel (Hutchinson), the epiphysis together with the epiphyseal line being in either case carried forward and slightly rotated backwards (Fig. 81). To the epiphysis are attached both heads of the gastrocnemii, the popliteus, and most of the ligaments of the knee, so that in young children this accident generally replaces dislocation of the knee-joint (Hutchinson).

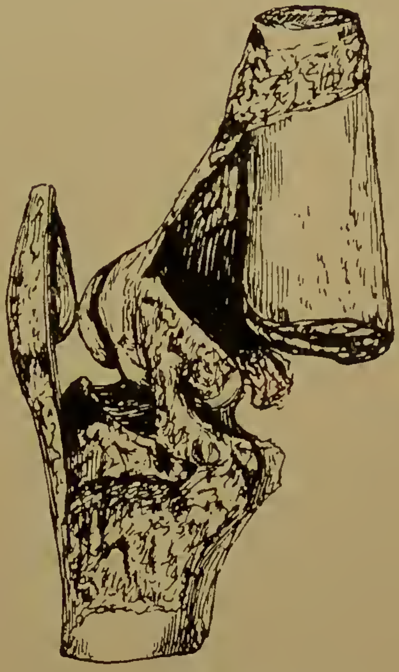

FIG. 81.—SEPARATED LOWER EPIPHYSIS OF FEMUR. (London Hospital Museum, No. 480A.)

Separation may be partial or complete, but the periosteum is rarely completely torn. In the complete variety the lower end of the diaphysis is very prone to press upon and obstruct, or to lacerate, the popliteal vessels. Not uncommonly the injury may be compound, either the diaphysis or epiphysis projecting through the skin. Much more rarely the epiphysis may be displaced laterally, and is then often rotated, so that the leg may even form a right angle with the thigh when seen from the front (J. Hutchinson).

Symptoms.—The child will be in very great pain, and will have lost all use of the leg. The knee-joint will be much swollen, so that an accurate diagnosis of the condition present may be difficult. The leg as a whole may be displaced forwards or laterally, with a depression in front over the lower end of the diaphysis, and a corresponding prominence behind in the popliteal space. There will be increased mobility, which in the early stages can generally be distinguished from movement at the knee-joint by the fact that lateral movements are more marked. In some cases of partial separation a soft crepitus may be obtained. A radiograph may be required to confirm the diagnosis.

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[1] *Brit. Med. Journ.*, July 16, 1887.

Treatment.—Hutchinson and Barnard[1] have shown that it is easiest to overcome the deformity and to maintain the fragments in position when the knee is fully flexed.

An anæsthetic should be given, so as to thoroughly overcome all muscular spasm. An assistant now makes strong and steady traction upon the leg in the line of the femur. The operator then clasps his hands beneath the lower part of the thigh, and draws it steadily upwards, flexing both hip and knee joint, the assistant maintaining the extension upon the leg. By this means the epiphysis moves backward on the lower end of the femur, both the anterior displacement and the rotation being overcome. The limb is now bandaged and laid on its outer side on a pillow, being flexed at an angle of about 60°.

No splint will usually be required to maintain this position, but, if desired, an external angular one can be applied. With this method, massage should be commenced on about the fourth or fifth day, very gentle passive movements being added after about two weeks. The patient should not be allowed to walk until five or six weeks after, the knee and leg being at first supported by a divided plaster, while massage and movements are continued daily.

If the epiphysis cannot be reduced by the above method, an open operation should be undertaken. An external lateral incision will usually be sufficient. The deformity is reduced by manipulation as above, aided by leverage through the open wound.

When in position, there may be no tendency to recurrence, and therefore no fixation apparatus may be required. If necessary, an external staple or a screw passing obliquely through the shaft into the diaphysis should be used. In either case the metal bond of union should be removed as soon as the epiphysis is firmly united. Handley[1] records a case where neglect of this precaution was followed by genu-valgum. In his case a semicircular incision dividing the ligamentum patellæ was necessary. Lane[2] records another where genu-varum occurred, the foreign body apparently limiting growth here.

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[1] *Lancet*, May 13, 1899.

In some cases it may be necessary to remove a small portion of the diaphysis in order to bring about reduction.

If the injury be compound, the parts must be thoroughly cleansed, the end of the diaphysis being, if necessary, touched with pure carbolic acid, or a small piece sawn off. The deformity is then overcome, and the parts fixed if there be tendency to recurrence. The after-treatment will be similar to that of the simple cases.

PROGNOSIS.

In young children the results of fracture of the femur are generally extremely good. Union takes place readily, and within two or three months the child is running about, none the worse for the accident. Any slight local deformity will also tend to disappear in the course of time.

With adults, however, the matter is very different, and a fracture of the femur must always be looked upon as a serious injury, which may result in many months', or even permanent, inability to return to work. Not only does union take a relatively long time to occur, but resulting weakness may take many months to be recovered from, while even slight alterations in the axis of the bone may lead to changes in the articular surfaces of the joints, and prevent the patient from returning to heavy work, such as that of a labourer, perhaps for several years. For this reason it is essential that good position—anyhow, as regards angular deformity—be always obtained. Slight shortening will lead to much less severe results. Gibbons[3] found only three recoveries out of ten cases in different positions. The others had all been watched for fourteen months or more, and he states that none of them would be likely to return to their work. As he points out, however, these patients had been treated by the application of rigid plaster cases, a method which, as has been already shown (p. 26), is likely to lead to bad results.

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[1] *Trans. Roy. Med. Soc.*, November, 1908, Clin. Sect., p. 1.
[2] *Annals of Surgery*, December, 1909, p. 1111.
[3] *Brit. Med. Journ.*, February 5, 1910, p. 314.

As regards the individual fractures, those of the neck in elderly women are probably hardly ever followed by bony union, so that in many instances a retentive apparatus, such as a Thomas's hip splint, may have to be worn for the rest of their lives. In others the fibrous union may be sufficiently firm to allow them to walk without this aid, but even here pain and stiffness in the joint will probably persist. In younger people bony union will probably be obtained, but only after prolonged fixation, generally about three months in all, and is then followed by considerable stiffness of the affected joint, or even absolute ankylosis. Even in the most favourable cases, a year to eighteen months must, in compensation cases at any rate, be regarded as the length of time of incapacity. Open operation is not followed by a very much shorter convalescence, for the separated fragment is so small, and lies at such a depth, that absolute fixation in a perfectly corrected position is extremely difficult.

In fractures through the trochanters the outlook is rather more encouraging. Here active treatment is generally required for rather over two months before the patient is allowed to try and walk without any instrument. Pain, with limitation of movement, will generally persist for some months more. Of course much will depend upon the amount of deformity. If this be definite, alterations in the hip-joint, especially of the nature of osteo-arthritis, are more likely to result, so that the patient may continue to draw compensation for several years. In favourable cases he may be able to return to his work in six to twelve months.

Separation of the upper epiphysis is nearly always followed by a certain amount of coxa vara. This may be lessened, but is very rarely entirely prevented by prolonged extension. In some cases it may be sufficiently marked to cause pain, limping, and adduction, and may give rise to a noticeable scoliosis, so that subsequent subtrochanteric osteotomy may be called for to remedy the deformity. In any case at least six months' active treatment is required; and even if the deformity be then only slight, probably two to three further months will elapse before the patient has sufficiently accommodated himself to his altered conditions to participate in laborious duties.

Fractures of the shaft in young or middle-aged men necessitate prolonged treatment, but, provided that the position is good, are ultimately completely recovered from. The period of convalescence is prolonged owing to the fact that the splints used, and more especially the extension apparatus, largely prevent early and efficient massage and passive movements, so that a course of these, often of necessity long continued, has to be carried out after the splints are removed. Nor is this period much shortened in cases where open operation is undertaken, as, owing to the weight of the limb, a retentive apparatus has always to be applied in addition, so that, provided good position can be obtained without, there is no indication for operation on the ground of length of treatment alone. Even in straightforward cases two and a half to three months may elapse before all splints are left off, and another two to three months before massage and passive movements can be dispensed with. At least six months should be allowed before the patient can be certified as fit for heavy work.

Many patients, however, complain of pain, weakness, and stiffness, for months longer than this, and are often given compensation on these grounds. It is always difficult to determine in these cases what proportion of the symptoms is dependent upon the question of compensation, but certainly some cases, where this consideration is absent, are unable to return to their full work until a year or eighteen months has elapsed; but this should be the limit, provided that there is no complication, that there is good apposition and firm union, and that no definite joint changes are present.

In fractures of the lower extremity involving the joint the results are often poor; even if the fragments are firmly fixed together in good position, slight osteo-arthritis may result, whilst if fitted together less accurately this condition will be correspondingly increased. In satisfactory cases of this nature, however, there may be very nearly complete restoration of function in six months, provided that massage and passive movements are commenced early. The chief reason for prolonged disability in simple cases is the associated rupture of ligaments. If the crucial or lateral ligaments be ruptured, the joint will probably remain weak permanently and necessitate the constant use of some supporting instrument.

CHAPTER XIV

FRACTURES OF THE PATELLA

Fractures of this bone are of common occurrence, and are found most frequently in young or middle-aged muscular men. Two different types may be recognized—those due to muscular and those due to direct violence.

Due to Muscular Violence.—This is much the more common variety. It is due to sudden contractions of the quadriceps muscle made during attempts to avert a fall, the usual history being that the patient, while carrying a weight on his back, slipped, and made a sudden effort to support himself, throwing his body backwards in order to do so. A snap is then often heard in one knee, there is a sudden severe pain in it, the patient falling to the ground, and then finding that he has lost the power of extending the affected limb, the knee of which rapidly swells. Equally commonly he is walking downstairs, when one foot slips, and the body is thrown back to save himself from falling. The same series of symptoms follows. In some rare cases such an accident as the latter is followed by fracture of both patellæ, as in cases reported by Mansell Moullin[1] and Sheen.[2] The mechanism of these cases is as follows: The knee-joint being flexed slightly, the patella is balanced on the anterior portion of the articular surface of the femur. Sudden contraction of the quadriceps then snaps the patella across, the femur acting as a fulcrum. Rarely the ligamentum patellæ may be torn instead. In some cases fracture is largely dependent upon previous disease of the bone, as in a case recorded by Johnson[3]—a matter of importance, in that successful operative treatment is made much more difficult. The line of fracture is nearly always transverse, and the aponeurosis over the front of the bone is nearly always torn completely across. The upper fragment is then pulled up by contraction of the quadriceps, so that a separation of 1 inch to 1½ inches occurs between the two portions, the amount of separation increasing when the knee is flexed. The lower fragment is rotated, so that the fractured surface, instead of looking directly upwards, looks upwards and outwards, probably from the greater elasticity of the anterior fibres of the ligamentum patellæ (Fig. 82). The joint is always involved.

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[1] *Surgery*, 1891 edit., p. 474.
[2] *Lancet*, November 13, 1909, p. 1425.
[3] *Trans. Roy. Med. Soc.*, December, 1908, Clin. Sect., p. 29.

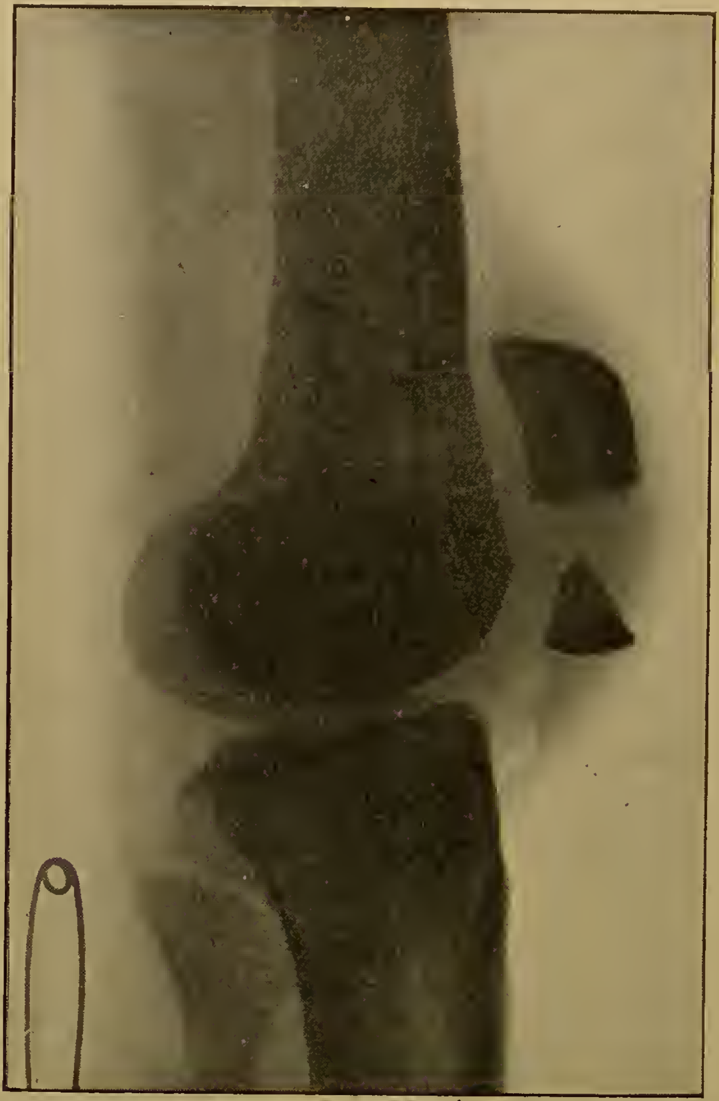

FIG. 82.—TRANSVERSE FRACTURE OF PATELLA FROM MUSCULAR VIOLENCE; FRAGMENTS SEPARATED, LOWER TILTED: BEFORE TREATMENT. (Mr. Furnivall's Case.)

The torn aponeurosis projects over the fractured edges, curling in over these surfaces. This factor is one of the most important preventatives to obtaining accurate apposition by any means other than operative. Rarely the aponeurosis, even in this type of fracture, is not torn, and but little separation therefore results.

If treatment be not carried out, the quadriceps muscle continues to contract, the upper fragment being pulled farther away from the lower, until a gap of several inches may result. Owing to fibrous changes in the muscle, it will be then often impossible to return the upper fragment to its normal position. The condition is very occasionally compound, when sepsis is almost certain to result.

Symptoms.—There is complete loss of power of extension, and the patient is therefore unable to walk unaided. There is much pain and swelling of the affected knee. On examination, the outlines of the joint are very prominent, the cavity being filled with exuded blood and serous fluid, which also forms a prominence in front, either into or beneath the prepatellar bursa. On making dipping movements into this with the fingers, or even by direct pressure, a marked gap is felt between the two fragments, this being usually about 1 inch wide and increasing on movements of flexion. Within a few days the surrounding skin becomes deeply discoloured from absorption of the effused blood.

Treatment.—In all such cases as the above open operation should be undertaken. It is only by such means that the tilting of the lower fragment can be accurately overcome and the turned-in aponeurosis removed from between the fractured surfaces. If operation be not performed, fibrous union only will occur, a prolonged period will result before even that is firm, during which time the joint has to be immobilized, and resulting adhesions, largely due to the effused blood, are certain to occur. Subsequent movements to remedy this are prone to again separate the fragments, so that a joint always weak, without the power of forcible extension, and generally associated with much limitation of movement, is very likely to result.

Open operation, on the other hand, will permit removal of all the effused blood and firm fixation of the two fragments, so that passive movements may be commenced early and all adhesions prevented. It should therefore always be advised, unless some grave counter-indication be present.

The majority of surgeons prefer to place the affected limb on an inclined plane, supported by sand-bags, for the first few days, and to apply evaporating lotions, so as to limit the amount of effusion into the joint, and to allow the traumatic inflammatory changes to subside. Sir Watson Cheyne,[1] however, advocates immediate operation, and has found no reason to regret doing so.

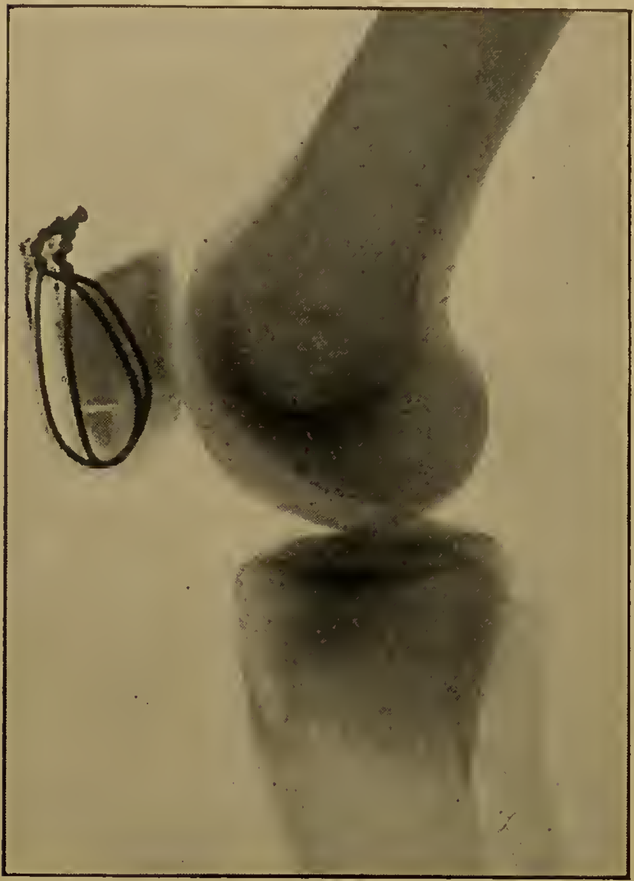

FIG. 83.—TRANSVERSE FRACTURE OF PATELLA, AFTER TREATMENT. (Mr. Furnivall's Case.)

The nearer wire appears to be loose ; this is due to the presence of the aponeurosis, which gives no shadow.

Several forms of incision have been used. Some surgeons prefer a vertical incision over the middle of the patella ; others advocate a curved incision, the transverse portion being above and the flap turned downwards. The most generally used, and perhaps the most satisfactory, however, is to turn a flap upwards. The incision is a curved one, and so fashioned that the transverse portion runs across the patellar ligament midway between the patella and the tubercle of the tibia. In this site it will be free from pressure while the patient is in the kneeling position. The ends are curved round so that they run up on either side of the patella, and about 1 inch away from it, until they are level with the lower border of the upper fragment. This incision is advantageous in that it may be continued as far as necessary up the thigh, in order to gain control of the upper fragment. A flap is much preferable to a vertical incision, as the scar is then remote from the ends of the wires.

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[1] *Manual of Surgical Treatment*, part iii., p. 137.

The flap is reflected upwards, and the rent in the capsule of the joint will now become apparent, while the two fragments with the gap between them, leading directly into the joint, will be visible. All blood-clot is now gently removed from the joint cavity with a pledget of gauze on a holder, special attention being given to the two lateral pouches, and care being taken not to injure the underlying synovial membrane and articular cartilage. A pad of gauze, such as is used in abdominal surgery, may now with advantage be laid across the joint beneath the two fragments, so as to protect it during the drilling of the fragments and insertion of the wires. Attention is now given to the fractured surfaces. These are gently scraped with a sharp spoon to remove all blood-clot, and the turned-in aponeurosis is elevated. If possible, it should be preserved, so that it may later be sutured over the line of fracture; but if it tend to constantly fall between the fragments, it may be removed with scissors.

The fragments are now drilled, this being most simply accomplished as follows: The fragment on the surgeon's right hand—*i.e.*, the lower in the case of the right leg, the upper in the left—is first dealt with. Two small vertical incisions are made through the aponeurosis down to the outer surface of the bone, as far as possible from the fractured surface. The drill, which should preferably be a hand one, is now introduced through these, and the fragments then bored obliquely, the drill emerging on the fractured surface (see Fig. 9, p. 39). If the two fragments be now brought together, the fractured surface of the undrilled fragment may be marked with the drill at two corresponding points.

The two ends of a long piece of silver wire of No. 5 gauge are now passed down these holes to emerge on the fractured surface. The other fragment, being now rotated and steadied, is drilled obliquely from the fractured to the outer surface, the point of the instrument being entered at the two marked spots. By drilling one fragment from without in, and the other from within out, the surgeon can always use his right hand without altering the position of his body, and absolute apposition of the openings on the two fractured surfaces can be obtained. Two wire cannulæ of appropriate size are passed down the holes in the second fragment from without inwards, their points emerging on the fractured surfaces; the ends of the wires are passed up them from below, and they are then removed.

The fragments are now drawn firmly together by means of a pair of lion forceps, and steadied by an assistant. The two ends of the wire are seized with forceps—sequestrum forceps are most useful for this purpose—and pulled as tight as possible. The ends are then twisted round for one or two turns, the excess cut off with wire cutters, and the twisted ends hammered down into the bone.

By this means a mattress suture is inserted (see Fig. 9, p. 39). Some surgeons always use two separate wires, or even only one wire, but at times these cut their way out, if the patient happens again to slip before bony union is completed. With a mattress suture this is impossible, as the strain is diffused over a long area of wire running across the fibres of the aponeurosis, so that even with very soft fragile fragments a perfectly firm grip is obtained, and if passed as advised above it takes no longer to insert than two separate sutures. Quenu drills the fragments from side to side. Some surgeons use a chromic gut or kangaroo tendon suture instead of a wire one, but they are more likely to fray on the cancellous bone, and thus give way. Gibbon[1] has advocated suture of the aponeurosis only, without a suture passing through the bone; but here less accurate apposition of the joint surface is likely to be obtained, and, the union being less firm, it would be unwise to allow any strain to be borne on the knee until bony union had taken place—*i.e.*, about six weeks.

The gauze pad beneath the patella is now withdrawn, and the torn aponeurosis carefully sutured with chromic gut, the joint being thus closed at the sides of the patella. Any bleeding-points are ligatured, and the skin wound sutured without the use of drainage. Throughout the operation it should be the aim of the surgeon never to introduce his fingers into the wound, however carefully cleansed and gloved they may be. A massive dressing is now applied, and the patient returned to bed with the knee slightly raised on a pillow, but no splint used. On the third or fourth day slight movements are allowed, excessive movements being prevented by the dressings. At the end of ten days the stitches are removed, and passive movements with gentle massage commenced, the patient being encouraged to use the limb. At the end of two weeks he may be allowed to get up and walk with the aid of two sticks. By this means he is usually able to walk perfectly well without any assistance at the end of four to five weeks, the strain being borne by the wire until bony union is complete. Perfectly normal function should be regained.

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[1] *Annals of Surgery*, June, 1904, p. 1023.

It is unnecessary to remove the wire if asepsis has been maintained, and if a flap incision has been made, as the ends are not then under the scar.

In old-standing cases, where no treatment has been applied at the time of the accident, it may be sought owing to the resulting disability. The fragments are united only by fibrous tissue which has stretched, so that they are widely separated, and control of the leg is lost, this being especially noticeable when the patient attempts to walk up or down an incline or up stairs. The power of forcible extension of the knee will be lost.

In these cases secondary changes will make the treatment more difficult and prolonged. Not only are the fragments separated, but the quadriceps muscle has undergone secondary shortening, so that they can no longer be approximated. There will also generally be adhesions between the two fragments and the anterior surface of the femur or tibia, and perhaps even between the articular surfaces of the femur and tibia.

It is usually advised that in such cases an incision be made as before, the two ends being carried farther up the thigh, so that the upper fragment may be reached. Any fibrous tissue between the two fragments is divided, and adhesions between the fragments and the femur or tibia also cut. The fragments are then drawn together as far as possible, but it will usually be found that they fail to approximate by an inch or so. To overcome this, some form of muscle lengthening is usually advocated. This may be done by making several lateral incisions on either side of the muscle, those on one side interdigitating with those on the other, or, as Sir Watson Cheyne[1] advocates, dividing the muscle across by an exaggerated zigzag incision, so that when separated several interdigitating processes are left, these being drawn asunder and their apices stitched. All such methods, however, lead to considerable after weakness of the muscle, and to prevent this Lynn Thomas[1] advises that an external incision be made, and the tubercle of the tibia chiselled through on its outer side, but leaving the attachment of the quadriceps tendon on the inner side uncut. By this means the lower fragment is brought up to the upper, but the amount of mobilization gained is slight, and hence it is of limited value. In either case a mattress suture should be used.

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[1] *Manual of Surgical Treatment*, part iii., p. 137.

Undoubtedly, if the patient can be persuaded to undergo two operations, the method devised and successfully carried out by Lord Lister[2] promises to be the most valuable. Two short vertical incisions are made over each fragment. The upper is drilled with two holes, and a long wire passed through these in the form of a mattress suture. A broad raspatory is passed into the lower incision, and the soft tissues freed from the front of the femur, so that the two wounds communicate. With a pair of forceps inserted into the lower wound, the ends of the wire are drawn down, and two holes are drilled in the lower fragment. The ends of the wire are now passed through these from within outwards, and the upper fragment is drawn down as far as possible with a strong sharp hook, the thigh being fully flexed and the leg extended. The ends of the wire are then fixed. By this means the two fragments are brought to within an inch or less of one another and firmly held together. The wounds are now closed and a dressing applied. The leg is gradually lowered, and the quadriceps thus stretched. The patient is allowed to walk about, and thereby the muscle is still further stretched. When all movements are free, the second operation is performed. The fragments can now be approximated, but flexion of the thigh with extension of the knee may be required to accomplish this. The surfaces are freshened, and the two portions firmly fixed in good apposition, the wound being then closed.

The after-treatment will be similar to that after the first operation.

[1] *Brit. Med. Journ.*, May 16, 1908, p. 1161.

[2] *Lancet*, April 11, 1908, p. 1049.

Previously several forms of treatment which attempted approximation of the fragments without an open operation were advocated, owing to the fear of sepsis, which sometimes resulted with the open method. Such was Barker's method of passing a wire suture around the fragments from behind forward through a skin puncture, the joint being here entered; or Butcher's method of using a circumferential wire suture; or that introduced by Mayo Robson, of passing two short pins through the ligament above and below the fragments, and approximating these by means of "figure-of-eight" knots. They all suffer from the disadvantage that the tilting of the fragments and the interposition of the aponeurosis are not overcome, so that fibrous union will alone result; whilst the introduction of such bodies is almost as likely to be followed by sepsis as an open operation.

In present-day surgery this fear of sepsis is absent, and, thus, the only counter-indication to open operation should be a condition of the patient's health unfitting him for any operative measures, such as lesions of the heart or lungs, diabetes, Bright's disease, etc.

Palliative Measures.—In a few cases such as the above, measures other than operative may have to be undertaken. The leg may be placed on a long back splint with a footpiece, and raised on a high inclined plane, so as to relax the quadriceps muscle as much as possible.

Evaporating lotions are then applied to limit the effusion. In a few days attempts are made to approximate the fragments. The lower fragment is fixed by passing strips of adhesive plaster obliquely upwards and backwards around the leg and splint. These must pass in front over the ligamentum patellæ. A piece of moleskin plaster is now cut to fit round the front of the thigh, a gap being cut below which fits round the upper fragment of the patella. This is strapped in position round the thigh. To its lower edges on either side straps are fastened, so that when extension is applied to them the upper fragment is pulled down. Continuous extension is usually made in the form of two strong elastic bands, passing down to be attached to the footpiece of the splint.

This apparatus will have to be worn for two months or more, gentle massage, especially in a downward direction, and movements of the patella, being made in the later weeks.

A well-fitting divided plaster is now made for the knee, and the patient allowed to walk with crutches. He may be encouraged to gradually make use of the limb, while massage and passive movements are continued.

By this means fibrous union will, as a rule, alone be obtained, and the prolonged fixation will almost certainly cause fibrous ankylosis of the joint, which is with difficulty overcome, passive movements being likely to again separate the fragments. The muscles also undergo marked wasting. Very rarely bony union may result even with considerable separation (Fig. 84).

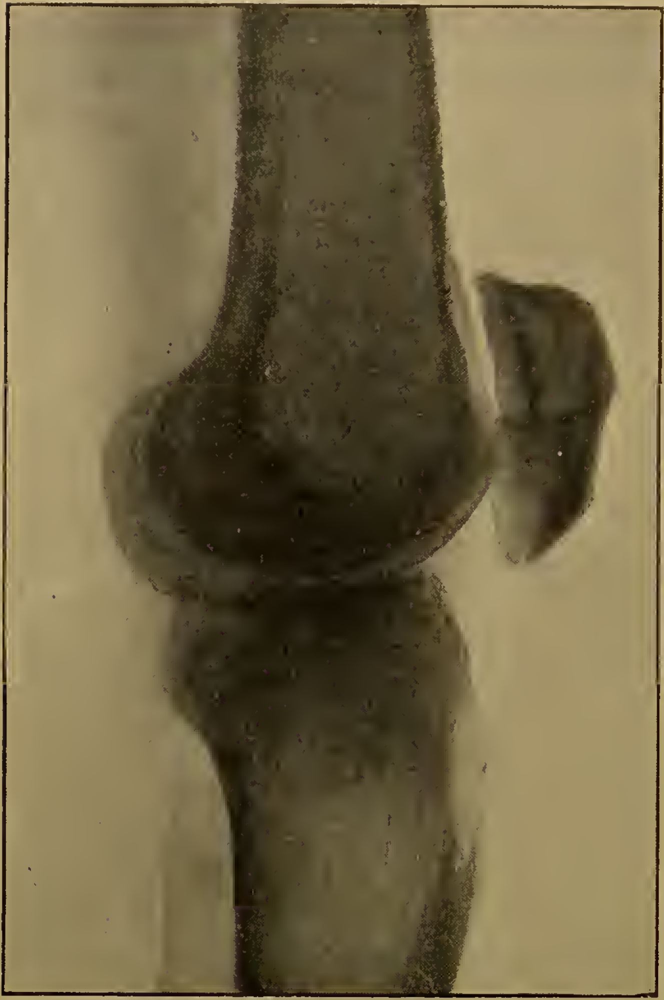

FIG. 84.—BONY UNION TWELVE YEARS AFTER FRACTURE FROM MUSCULAR VIOLENCE, TREATED WITHOUT OPERATION. (Mr. Dean's Case.)

The tilting of the lower fragment has persisted.

Better results are sometimes obtained by the use of Malgaigne's hooks. These are sharp hooks which are inserted through the skin or through small incisions made to receive them. They hook over the upper and lower edges of the respective fragments, and are then approximated by screwing. They thus draw the fragments into good position, so that, although the bony surfaces are still separated by the aponeurosis, and some tilting persists, movements of the knee-joint can, in part at least, be carried out, and thus ankylosis prevented or lessened while fibrous union is taking place. In some cases bony union appears to follow the use of these hooks, as in a case recorded by

Barnett.[1] They should be left in position four to five weeks, being protected by aseptic dressings. They do not enter the joint, but must, of course, be inserted with every aseptic precaution.

In the rare cases where the fracture is compound, attempts must be made to render the wound aseptic. An anæsthetic being given, the wound is plugged with gauze, and the surrounding skin shaved, and then thoroughly cleansed by scrubbing with soap and water and by the application of turpentine, ether, and biniodide of mercury in spirit. The packing is now removed and the wound washed out with 1 in 40 carbolic solution, any visible foreign material being removed. The ends of the patella are turned outwards, the fractured surfaces scraped and swabbed over with pure carbolic acid, the joint being protected by gauze pads. The whole joint and the fragments are now washed thoroughly with saline solution to remove all traces of the carbolic acid, and the fragments fixed by wiring. A small tube should be inserted, to be removed in forty-eight hours if no suppuration occurs. If sepsis should occur, the joint must be thoroughly opened and drained, fomentations applied, or, if necessary, continuous irrigation used.

Due to Direct Violence.—This type of fracture is much less common than the last, and arises from blows directly over the patella. The fracture may then be comminuted or star-shaped, or a single longitudinal or transverse fissure (Fig. 85) may occur. As a rule the aponeurosis is untorn, so that separation of the fragments is very limited, but even in these cases the joint is often involved, so that there is much pain and swelling.

Symptoms.—The patient will complain of pain and tenderness in the affected limb following a blow. There may be but little incapacity, many when the aponeurosis is untorn being able to walk. The joint is, however, often swollen, owing to the effused blood, but if it be uninjured even this will be absent. In these cases there will only be the local pain and tenderness, the pain being increased by powerful movements of extension, such as in running, going up stairs, or attempting to kick any object. A diagnosis may here be definitely made only by the use of radiography, and it is important to remember that in younger patients the condition may be simulated when two centres of ossification are present in the patella. Here, however, the two fragments appear more rounded, and the condition is often bilateral.

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[1] *Lancet*, January 19, 1907.

Treatment.—The patient should be kept in bed on a splint, lest forcible movements of extension lead to rupture of the aponeurosis and subsequent separation. The splint should be worn for about three weeks, daily massage and passive movements being given. At the end of that time bony union will probably have taken place, and exercise is gradually permitted. If the aponeurosis be ruptured and there be much separation, the condition must be treated as one due to muscular violence.

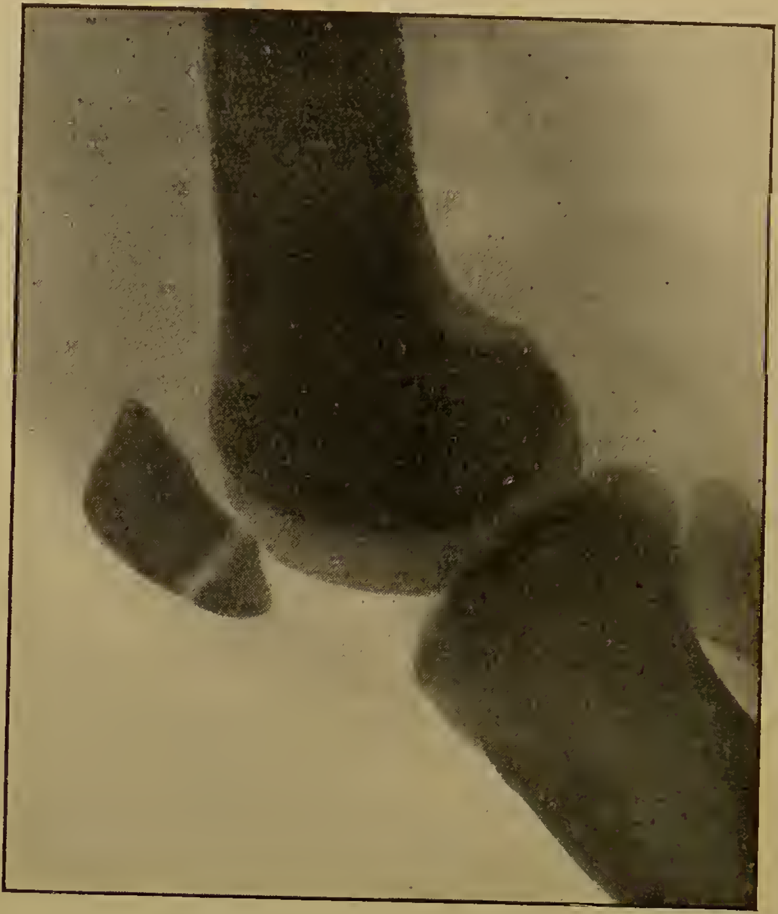

FIG. 85.—TRANSVERSE FRACTURE OF THE PATELLA FROM DIRECT VIOLENCE. (Mr. Dean's Case.)

The aponeurosis is untorn ; hence there is no separation of the fragments.

CHAPTER XV

FRACTURES OF THE TIBIA AND FIBULA

The Tibia.

Fracture of this bone alone is less common than fracture of both bones or of the fibula alone. It may arise from direct violence, or more rarely from indirect. The following varieties may be recognized (Fig. 86):

Of the Tuberosities [1].—Either one or both tuberosities may be separated from the shaft. In the latter case, the so-called "compression" fracture, the condition is generally due to falls on the feet from a height, in which case the tuberosities are driven up against those of the femur and separated from the shaft, which, being driven up between them, leads to considerable lateral displacement. Separation of one tuberosity may arise in the same way, the leg being then probably abducted or adducted at the time of the accident. More commonly separation of one tuberosity may be due to direct violence. Either variety is rare.

In all such cases the knee-joint is involved, and much subsequent disability may thus result. When both tuberosities are separated, there may be considerable shortening, even if the fibula be unfractured, this bone probably undergoing a certain amount of curvature, and

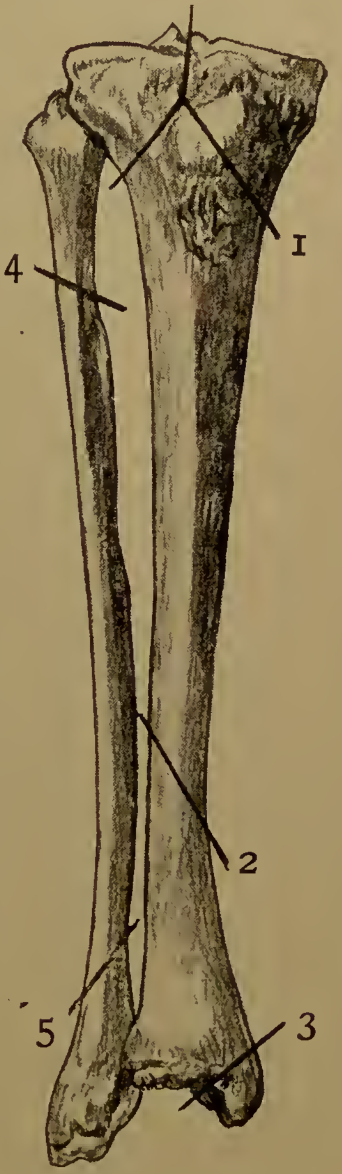

Fig. 86.—Tibia and Fibula, showing Sites of Fracture.

the shaft, the upper extremity of which is often pointed, then passing up between the two upper fragments, or even being impacted into them. When only one tuberosity is separated (Fig. 87), the leg will be markedly adducted or abducted, the corresponding tuberosity being depressed to a like degree. Such a lesion may be associated with fracture of the lower end of the femur.

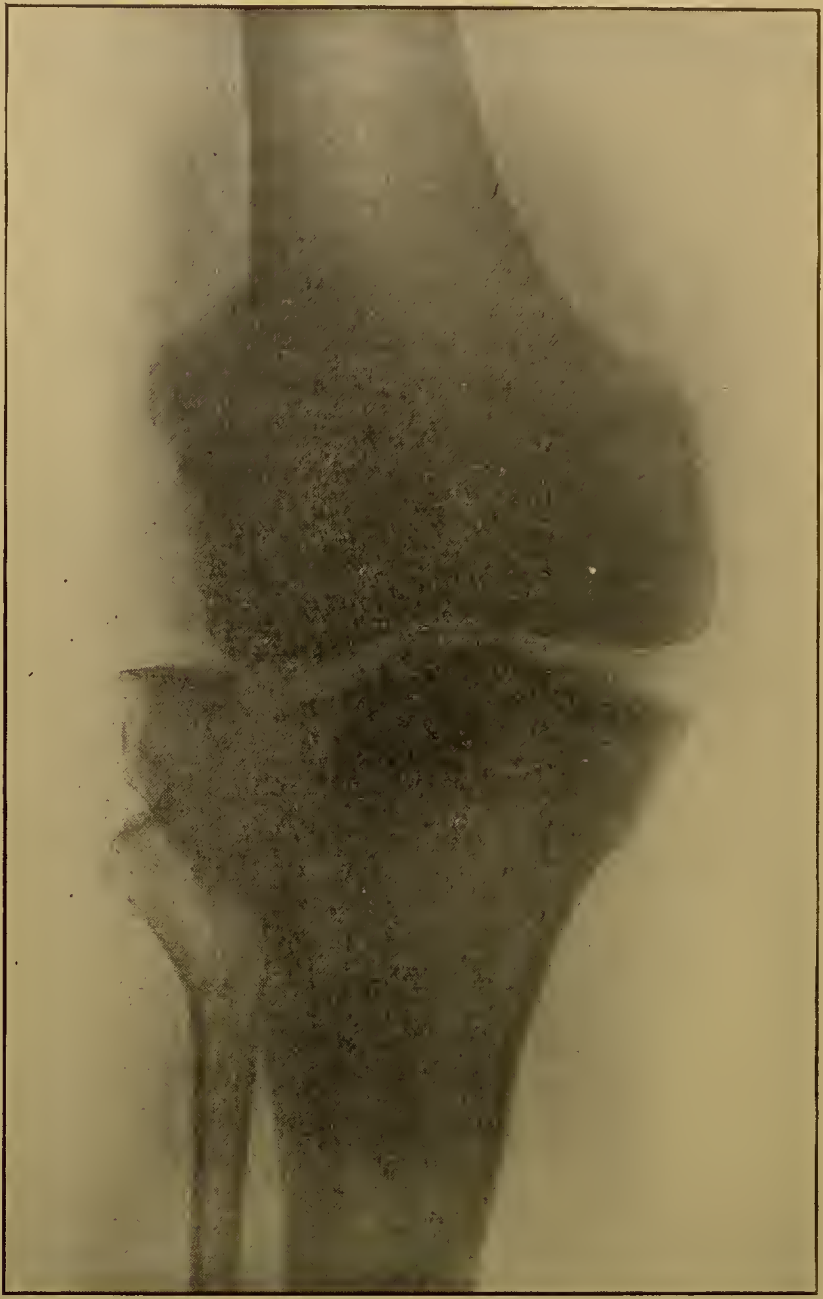

FIG. 87.—SEPARATION OF THE EXTERNAL TUBEROSITY OF THE TIBIA. (Mr. Fenwick's Case.)

Symptoms.—There will be loss of function in the affected limb. The patient will be unable to walk, and movements will be accompanied by considerable pain. The knee-joint will be swollen from the effused blood and synovial fluid, so that the outlines of the upper end of the bone will be obscured. If due to direct violence, this will be increased by extravasation into the surrounding soft tissues. Owing to this effusion, accurate diagnosis may at the time of the accident be extremely difficult, and it may indeed be impossible, until this has decreased, to decide whether the upper end of the tibia or the lower end of the femur be at fault.

In some cases, where the amount of swelling is less, widening of the upper end of the tibia, with irregularity of its outlines, may be discernible. The projecting portions of bone may be movable, especially in an antero-posterior direction. Shortening of the leg may be distinguished if both the tuberosities are separated, or abduction or adduction of the leg, when the injury is limited to one, the former sometimes being associated with outward dislocation of the patella. Unless there be impaction, lateral movements of the leg will be increased, and with these it may be noticed that the separated tuberosity does not move to a like degree. Crepitus will also by these means be obtained.

If impacted, the signs will be less marked, and beyond pain and swelling, associated with thickening of the upper end of the tibia, but little may be made out. In some cases the crucial or lateral ligaments will be torn, when the disorganization is more extensive, and movements at the joint will be more flail-like. In all cases a radiograph should be taken; otherwise partial separation of one tuberosity may be overlooked.

Treatment.—As in the case of other fractures involving a joint, it is essential that accurate apposition of the fragments be obtained; otherwise not only will the irregularity of the articular surface lead to pain and limitation of movement, but alterations in the alignment of the limb may be caused, which in the case of the leg will be followed by insecurity.

If the displacement be but slight, an anæsthetic should be given, and an attempt made to overcome the deformity by manipulation. In the case of separation of both tuberosities this will be aided by extension upon the leg, or, if only one be separated, by abducting or adducting the leg, the former movement being made when the inner tuberosity is separated, the latter when the outer is at fault. If deformity is by this means easily overcome, the limb should have some permanent extension applied. This may be done as follows: An ordinary extension apparatus is fitted, the adhesive strapping reaching only to the knee. A back splint reaching halfway up the thigh is now bandaged to the limb, and extension, which as a rule need not be more than 3 to 4 pounds, attached. A similar object can be attained by applying a back splint, with a footpiece, which reaches nearly to the knee, and resting the leg on a double inclined plane, the apex of the two planes being behind the knee-joint. This has the benefit of flexing the joint, and thus the contraction of the gastrocnemii and soleus is overcome. Extension is maintained by the weight of the leg tending to slide down the distal plane, while plantar flexion of the foot and rotation of the leg are prevented by the back splint.

Instead of this a flexed Macintyre's splint is usually advised, but here the presence of the footpiece prevents extension, and if this be removed plantar flexion of the foot is certain to occur.

In either case the leg should be kept in position for about two weeks, and gentle massage and passive movements then commenced, the extension and fixation apparatus being reapplied until the end of four weeks. A divided plaster is now fitted, and the patient allowed to walk with crutches, the affected leg being kept off the ground by a sling passing round the neck. In two more weeks he is gradually allowed to bear weight upon it.

If the fracture be impacted, a careful radiograph must be taken. If the displacement be but slight it should not be disimpacted, but if great the fragments must be separated. In the former case treatment as above will be carried out, in the latter as in the next variety.

When the displacement is considerable and not fully reducible by manipulation under an anæsthetic, an open operation should be undertaken. Without it the articular surfaces will be so altered that the function of the joint will be greatly impaired, and fixation to obtain union in this position will be required for so long a time that ankylosis of the joint will be almost certain to result. If the fragments be replaced and fixed by open operation, almost perfect apposition should result, and passive movements commenced very early will prevent ankylosis.

The position of the incision will depend upon the individual fracture. If only one tuberosity be separated, a vertical incision over it will be most valuable; if both, an anterior incision, or even an upward turned flap, may be required. In any case reposition is aided by an assistant extending, abducting, or adducting the leg. The separated fragment when restored to position is best fixed by a screw. If both be separated, they should be screwed to one another. It may then be unnecessary to fix them to the lower fragment, as this, especially if wedge-shaped, will maintain its position.

The wound being sutured, the limb is bandaged on a long back splint with a footpiece, massage and passive movements being commenced in a few days. The after-treatment will be similar to that for cases with no displacement.

Fracture of the Spine of the Tibia.—This is an extremely rare injury, always due to direct violence to the knee, the mechanism of production being but little understood. Probably there is lateral displacement of the tibia sufficient to allow the spine to be forcibly struck against one of the condyles of the femur. It may occur during wrestling, football, or from falls from a bicycle or cart. The knee-joint immediately after the accident is extremely painful, and rapidly swells. Locking in a semiflexed position is often present, and may remain in spite of attempts at reduction under an anæsthetic. The swelling of the joint either persists, or recurs after slight exercise.

In most cases, as in those recorded by Morris[1] and Jones,[2] the spine remains attached to the anterior crucial ligament, and, being usually displaced backwards, carries this structure with it. A radiograph may, as in Jones's case, show an irregular mass of bone in the centre of the joint.

Treatment.—If the condition be diagnosed, an open operation should be undertaken and the separated portion of bone removed. The condition is, however, very difficult to differentiate from a torn or displaced internal semilunar cartilage, and an operation may be undertaken for this lesion. The same incision will probably be best in either case—viz., a vertical or slightly curved one over the anterior part of the inner aspect of the joint.

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[1] *A System of Surgery*, Holmes and Hulke, 1883, p. 1039.
[2] *Annals of Surgery*, December, 1909, p. 995.

The separated spine should be pulled forward, carefully dissected from the crucial ligament, and this latter structure, wherever possible, sutured in position with chromic gut. The capsule and superficial wound are closed, and the after-treatment will be similar to that for removal of a displaced semilunar cartilage.

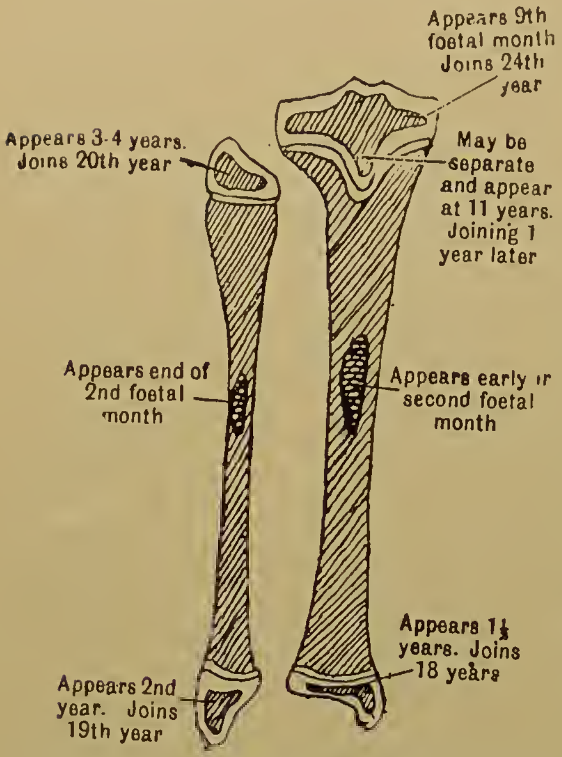
Appears 9th foetal month Joins 24th year
Appears 3-4 years. Joins 20th year
May be separate and appear at 11 years. Joining 1 year later
Appears end of 2nd foetal month
Appears early in second foetal month
Appears 1½ years. Joins 18 years
Appears 2nd year. Joins 19th year

FIG. 88.—OSSIFICATION OF TIBIA AND FIBULA.

Separation of the Upper Epiphysis.—A centre appears for the upper epiphysis at the ninth month of fœtal life, and joins with the shaft from the twentieth to the twenty-fourth year. The epiphysis includes the whole of the articular surface, the tuberosities, and the tubercle (Fig 88). Occasionally, however, this latter process has a separate centre, which appears about the eleventh year, and joins with the rest of the epiphysis at about the twelfth year.

Separation of this epiphysis is extremely rare, this probably being due, as suggested by J. Hutchinson,[1] to the fact that the ligamentum patellæ, the internal lateral ligament, and the semimembranosus tendon, are all inserted into both epiphysis and diaphysis. Separation may occur from violent wrenches and twists of the leg. In practically all cases the separation is only partial, and consists of a forward displacement of the epiphysis on the shaft. If the tubercle has a separate centre, violent contractions of the quadriceps may lead to separation of this process. Hutchinson mentions three cases recorded by Müller[2] and one by Ogilvie Will,[3] every one of which was due to vaulting over the horse in a gymnasium. The tubercle is then displaced upwards by the pull of the quadriceps tendon. If, however, there be no separate centre for this process, the whole epiphysis may be slightly tilted up in front, or the tuberosity fractured as well, conditions which are usually known as "Schlatter's disease." This condition may follow a sudden severe strain, or more commonly, as pointed out by Haglund,[1] the onset is slow, the patient complaining of tenderness on pressure over the insertion of the ligamentum patellæ, and upon all movements of extension, such as walking upstairs. The condition is more common in boys, and in the right leg, and is limited almost entirely to the age of between twelve and nineteen years. Either type of injury will be well shown by a radiograph.

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[1] *Brit. Med. Journ.*, July 16, 1887.
[2] *Die Rissfractur der Spina Tibiae Bruns' Beiträge*, 1887.
[3] *Brit. Med. Journ.*, 1887, vol. i., p. 15.

Treatment.—Separation of the whole epiphysis is best treated by reduction under an anæsthetic, with the knee in a flexed position. When deformity is overcome there is no tendency to recurrence, provided the knee is kept somewhat flexed, and for this reason the limb should be fixed to a Macintyre's splint, and kept in this position for three to four weeks, massage being commenced after one week, and gentle passive movements after three to four weeks. The splint may then be left off, and the patient allowed to walk with the use of a Thomas's knee splint, but no weight should be borne on the limb for a further four to eight weeks. At the end of this time he may be allowed to walk a little without the splint, but this walking must be limited to level ground. Climbing or descending inclines or going up stairs, which all throw strain upon the quadriceps, must be forbidden until all pain and tenderness have ceased. These may persist for as long as six months.

If the centre for the tubercle be entirely separated, open operation will be called for, as without this accurate apposition will be difficult. A vertical incision should be made and the separated portion pegged into position. If the joint be opened, extravasated blood-clot should be removed from it at the same time. The after-treatment will consist of prolonged fixation of the knee in the extended position until union is firm. The leg should therefore be placed on a long back splint with a footpiece, and it is best to keep it in this position for six weeks. Fortunately, in such young patients the tendency to ankylosis of the joint is much less than in adults. At the end of that time gentle passive movements may be commenced, active ones being refrained from until the end of ten weeks. Walking along level surfaces may then be gradually permitted.

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[1] *Lancet*, July 4, 1908, p. 12.

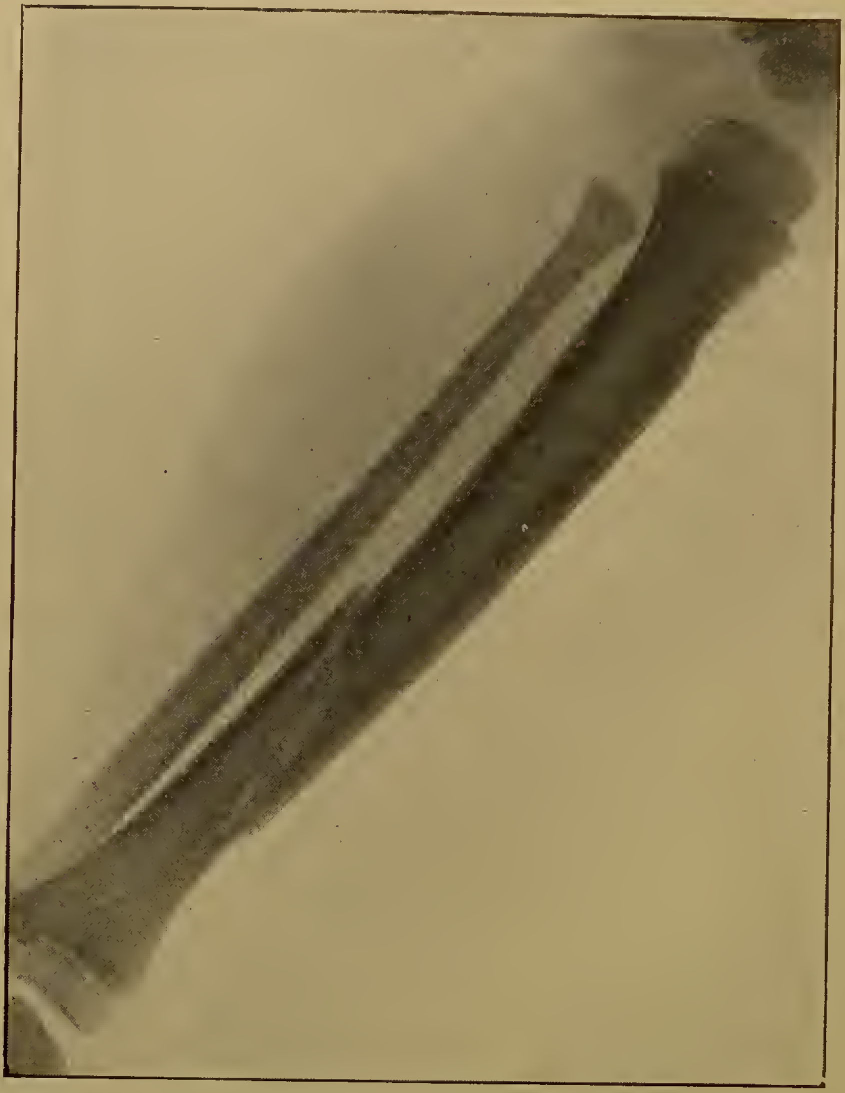

FIG. 89.—OBLIQUE FRACTURE OF TIBIA.
(Mr. Sherren's Case.)

With partial separation — "Schlatter's disease" — the patient should be kept in bed for two to three weeks, and walking on the flat then gradually allowed. Movements of extension are prevented until all pain has ceased. At times this may not occur until six months or more after the accident.

Of the Shaft [2].—Fractures of the shaft of the tibia alone are usually due to direct violence, such as the fall of weights upon the leg or direct blows. In some cases they may arise from indirect violence, such as a fall from a height. They are more common in younger patients. The site of the fracture is generally the line of junction of the lower and middle thirds of the bone, the fracture being oblique from behind, downwards and forwards (Fig. 89). When due to direct violence, fracture may occur at any spot, and tends to be transverse. In some cases the fracture is greenstick in nature, but in any case the amount of displacement is slight. There is a tendency to shortening, but this is limited in amount, owing to the presence of the fibula. When due to direct violence, the fracture may be compound, the wound then passing back to the sharp lower extremity of the upper fragment, which may perforate the skin.

Symptoms. — When the displacement is slight, there may be remarkably little incapacity, and the patient may even walk up for treatment. Usually, however, all pressure upon the foot causes very considerable pain, referred to the site of the lesion, and there is complete incapacity of the limb. Deformity will be very slight, but local swelling and bruising may be distinct. An irregularity of the anterior border of the tibia may often be felt with the finger, the lower end of the upper fragment projecting beneath the skin, and at times perforating it. If the lower part of the leg be firmly gripped in one hand, and the upper part in the other, abnormal mobility, especially to lateral movements, may be distinct, and crepitus may be elicited.

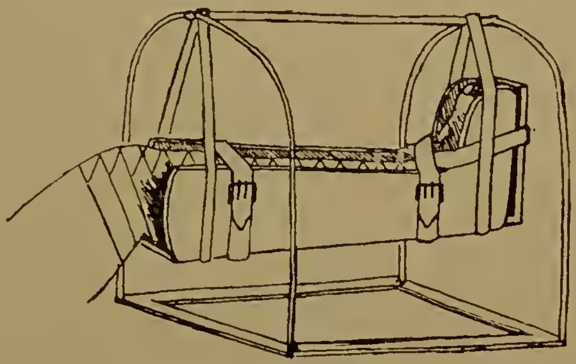

FIG. 90.—BACK AND SIDE SPLINTS APPLIED; LEG SLUNG IN A CRADLE.

Treatment.—Simple fractures without much displacement are best treated by being placed upon a straight back splint with a footpiece at right angles (Fig. 90). The splint should be well padded, and a small well-powdered cushion placed under the lower part of the tendo Achillis to prevent undue pressure upon the heel. A strip of boric lint is now placed over the footpiece so as to lie between it and the foot. In applying the splint, care must be taken that the alignment of the fragments is good, and that the lower part is not rotated. If the inner side of the big toe, the tip of the internal malleolus, and the inner side of the patella, be all in the same vertical plane, any rotatory deformity will have been remedied. The under-surface of the heel must also be brought down into contact with the footpiece; there is always a tendency for it to rise up, and thus for the foot to be somewhat flexed. If this tendency be not overcome, a certain amount of plantar flexion will persist afterwards and lead to considerable disability. The front of the leg is now well powdered with boric acid, and if there be any bruised areas a layer of cotton-wool is applied. Blisters, if present, should be punctured and covered with a piece of boric lint. The leg should now be firmly bandaged to the back splint, and two well-padded side splints then applied. By the insertion of pads beneath these splints a certain amount of lateral pressure may be exerted at any desired spot. The side splints should be attached by two straps, one encircling the leg below the knee, the other passing round the ankle, and then round the foot, to form a figure of eight. The leg is now slung in a Bloxam's cradle so that the muscles of the calf are relaxed, and so that movements of the trunk are less likely to disturb the upper fragment.

After two to three days, when the patient has become less restless, the side splints are removed, the leg remaining in position on the back splint. The bandage is then slit up and removed, and the lateral splints reapplied. Fixation being dependent upon the straps alone, the lateral splints can be taken off each day, and massage applied, the leg meanwhile resting upon, and being maintained in position by, the back splint.

At the end of seven days the back splint is each day gently slid down from under the leg, and passive movements of the knee-joint and ankle commenced, the fragments being held in position at the same time. After three weeks the splints are removed, and, if union be firm, a divided plaster applied. Union by this time will nearly always be firm if early massage as above has been used. When the limb is supported in this plaster, the patient is allowed to walk, massage and passive movements being continued daily. The plaster may be removed after two to three weeks.

If it be impossible to overcome the deformity, or if the fracture be compound, an open operation should be undertaken (see Fractures of Both Bones).

Non-union or malunion may result, but is much less likely to occur than when both bones are fractured.

Of the Internal Malleolus (Wagstaffe's Fracture) [3].—This generally results from direct violence, and there is but little displacement. It may rarely be caused by powerful inversion of the foot, thus resembling the more uncommon type of Pott's fracture, but the fibula is entire. In this case the fragment is displaced inwards. It may also occur as a part of the more common type of Pott's fracture, the foot being everted. In either case the joint is entered.

In the first case there will be bruising, pain, and swelling, over the internal malleolus; the fragment will, however, maintain its normal position, but, on being firmly gripped by the finger and thumb, movement and crepitus may be obtained.

If the fragment be displaced inwards, the foot will be markedly inverted, so that the sole of the foot may even face directly inwards. The external malleolus will be very prominent, and almost projecting through the skin. The inner side of the mortice of the ankle-joint being absent, the foot will also be drawn backwards, and plantar-flexed by the action of the tendo Achillis. In either case the amount of injury will be clearly shown by a radiograph.

Treatment.—In the first case it will be sufficient to immobilize the limb, so that muscular contraction, especially of the calf muscles, may not lead to separation of the fragment. For this purpose back and side splints should be applied, as advised in the case of a fracture of the shaft. Massage and passive movements should, however, be commenced from the very first. The splints may be left off at the end of two weeks, and the patient allowed to walk at the end of three, the foot being at first supported by a light divided plaster.

If there be much displacement inwards, the limb may be also fixed in back and side splints, but in this case the pad should be placed under the heel so as to prevent backward displacement of the foot, and the knee must be fully flexed so as to relax the calf muscles. Plantar flexion will be overcome by the footpiece. In correcting the inversion, care must be taken not to overdo the correction, as slight eversion causes more disability than a corresponding amount of inversion. These fractures are, however, best treated by reducing the deformity under an anæsthetic, putting on a Sharpe's splint, and continuing the treatment as in the case of a Pott's fracture (see Fractures of Lower End of Fibula).

Separation of the Lower Epiphysis.—The centre for the lower epiphysis appears about one and a half years after birth, and joins with the diaphysis at about the eighteenth year (Fig. 88); but the epiphyseal cartilage may be separated before the centre of ossification has appeared in it. J. Hutchinson[1] mentions cases where this took place during delivery.

The line of the epiphysis is situated wholly above the ankle-joint, so that this cavity is not entered.

The condition is generally brought about by excessive inversion or eversion of the foot, and this in younger patients takes the place of Pott's fracture. Pure separation is rare; generally a portion of the diaphysis is torn off, most commonly a wedge-shaped portion from behind being separated, whilst the lower end of the fibula is commonly fractured, either transversely or longitudinally (Fig. 91). The foot will then be everted or inverted and drawn backwards by the tendo Achillis.

Sometimes diminution of growth will follow this accident, and the tibia thus become curved from the unchecked growth of the fibula.

Treatment.—Reduction should always be brought about under an anæsthetic, and if the knee be fully flexed so as to relax the calf muscles, no difficulty will usually be experienced in this. When once the deformity is fully overcome, the leg should be placed on a Sharpe's splint, and treated on similar lines to a Pott's fracture.

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[1] *Brit. Med. Journ.*, July 16, 1887.

THE FIBULA.

Fractures of this bone alone, especially of the lower end, are very common, and are then nearly always due to indirect violence. Fractures higher up may be due either to direct or indirect violence.

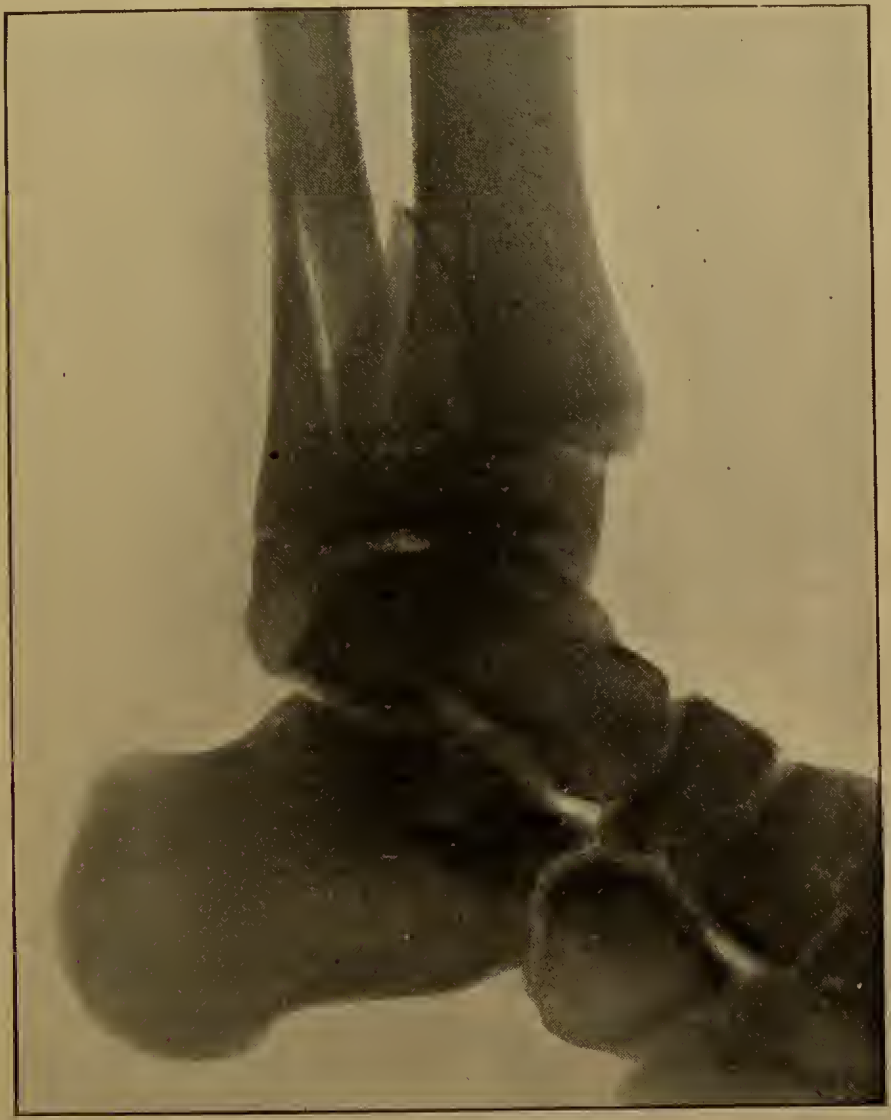

FIG. 91.—SEPARATED LOWER EPIPHYSIS OF TIBIA WITH OBLIQUE FRACTURE OF SHAFT. (Mr. Fenwick's Case.)

Of the Shaft [4].—Fractures of the shaft of the bone may arise from direct violence or from forcible eversion of the foot. In this latter case the bone is usually broken at its lower extremity, but may at times give way 4 to 5 inches above the tip of the malleolus, and is then often unassociated with injury of the ankle-joint. In either case the displacement is very slight, owing to the presence of the tibia, which acts as a splint. When due to direct violence, the fracture will take place at the site of the violence. Thus, the upper portion may show a transverse or comminuted fracture, perhaps accompanied by injury of the external popliteal or musculo-cutaneous nerve. If in the middle of the shaft, the tissues around will be considerably bruised, and the bone will tend to be broken transversely. Lower down the fracture is often oblique.

Symptoms.—The disability is slight; the patient is often able to walk when suffering from a fracture of this kind. Walking may, however, cause considerable pain, which is often referred to the site of the fracture.

On examination, some bruising and swelling may be found if due to direct violence, whilst if due to indirect violence the foot is often everted.

In either case forcible eversion of the foot will cause pain, and sometimes crepitus in the area of the fracture. Pressure over the injured bone will also give rise to pain, and on forcibly pressing the bone, and then suddenly removing the pressure, but keeping the fingers on the bone, the elastic sensation normally experienced, the "spring of the fibula," will be absent.

The condition may be only recognizable by radiography.

Treatment.—The patient should be placed in bed for a few days, and, if there be much swelling, evaporating lotions applied. At the end of this time a divided plaster may be fitted, and the patient allowed to walk, massage and passive movements being given daily. After about two weeks the plaster may be dispensed with, the patient walking with no support.

Of the Lower Extremity [5].—Fractures of this portion of the fibula are extremely common, and in the majority of cases involve the ankle-joint and are associated with displacement of the foot.

At times eversion of the foot may cause a simple fracture of the malleolus at or just below the inferior tibio-fibular articulation. The separated fragment may undergo no displacement, but pain on walking, and especially on eversion of the foot, is felt. Such a condition is often mistaken for a sprain, unless the presence of symptoms lead to an examination by the X rays.

Most commonly, however, the fibula is fractured about 2 to 3 inches above its lower extremity by indirect violence, and the foot undergoes partial dislocation. This condition was fully described by Pott,[1] and is hence usually known in England as "Pott's fracture." Strictly speaking, a Pott's fracture consists of a fracture of the fibula within 2 to 3 inches of its lower extremity, forcible eversion and partial dislocation of the foot outwards, and rupture of the internal lateral ligament of the ankle-joint. Several other similar lesions may, however, occur here from the same type of accident, so that the name has now come to be used some-

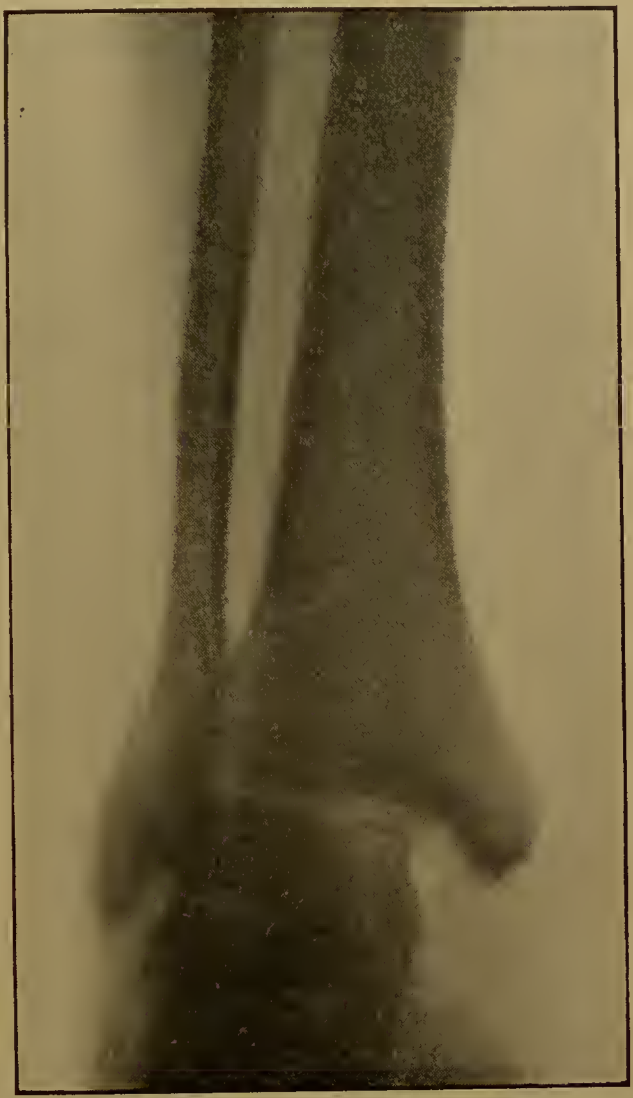

FIG. 92.—POTT'S FRACTURE: FRACTURE OF LOWER END OF FIBULA, EVERSION OF FOOT, AND RUPTURE OF INTERNAL LATERAL LIGAMENT. (Mr. Eve's Case.)

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[1] Pott's Works, by James Earle, 1790, vol. i.

what loosely, and the four following conditions may therefore be grouped together and considered here :

1. Fracture of the fibula with rupture of the internal lateral ligament and eversion.
2. Fracture of the fibula with fracture of the tip of the internal malleolus and eversion.
3. Similar lesions with inversion of the foot.
4. Similar lesions combined with rupture of the inferior tibio-fibular ligament.

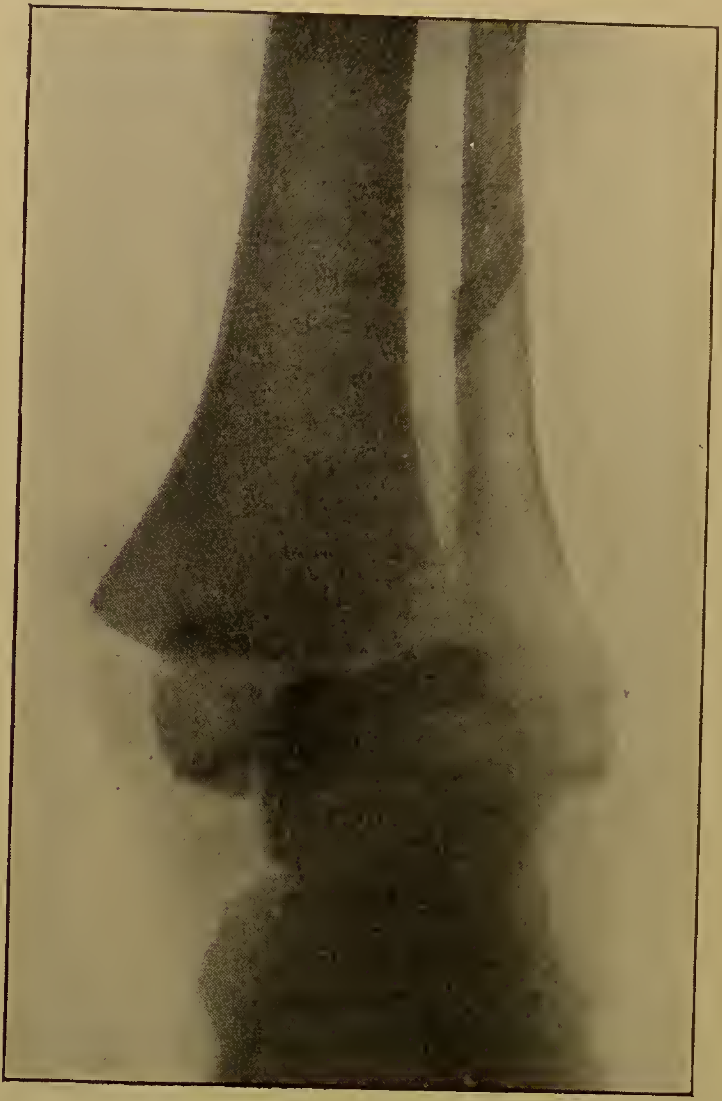

FIG. 93.—POTT'S FRACTURE : INTERNAL MALLEOLUS ALSO FRACTURED. (Mr. Fenwick's Case.)

The first two varieties are caused by forcible eversion of the foot. The patient often states that his foot slipped off the curb of the pavement, so that he fell heavily on to its inner side, or that while stepping off a moving vehicle, such as a bus or tram, with his foot looking outwards instead of forwards, the body was swung forwards and the foot everted. The outer surface of the astragalus is thus forcibly compressed against the external malleolus, which, being short and stout, does not give way; but the lower part of the fibula being firmly bound to the tibia by the inferior tibio-fibular ligament, it acts as a lever of the first class, the point of attachment to the tibia acting as the fulcrum. The whole of the shaft of the fibula is thus forcibly bent inwards, and breaks at its weakest point, within 2 to 3 inches of its lower extremity.

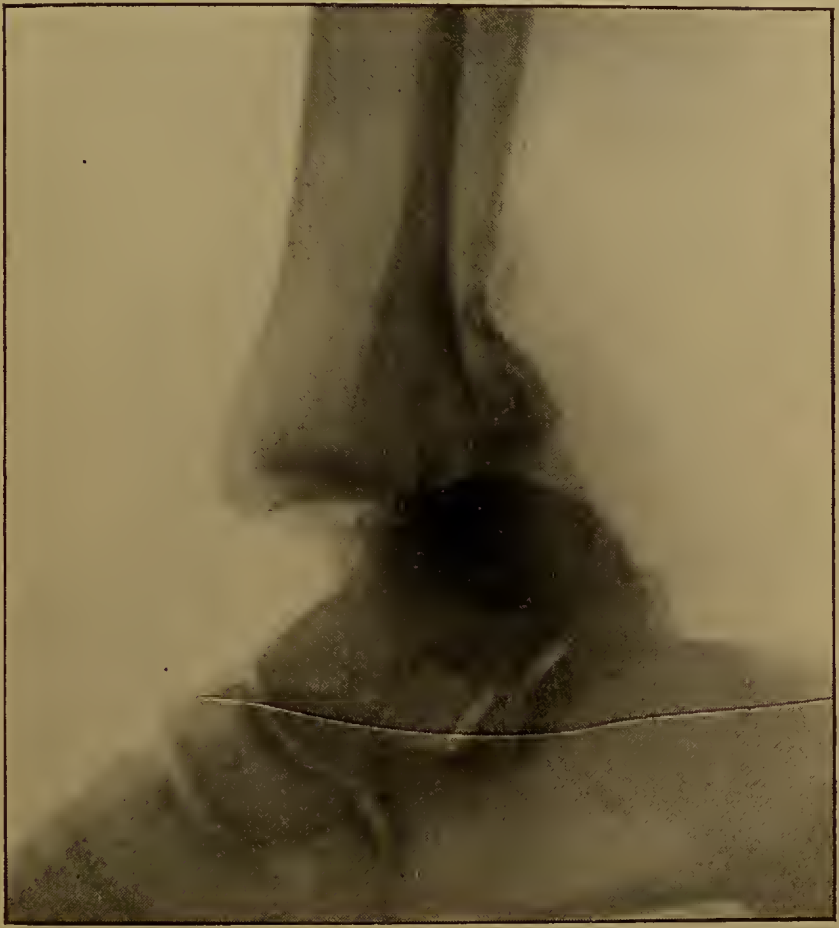

FIG. 94.—POTT'S FRACTURE: MARKED BACKWARD DISPLACEMENT. (Mr. Eve's Case.)

When once the external malleolus has thus been forced out, continued eversion is prevented by the internal lateral ligament alone, so that this is either ruptured (Fig. 92), or the tip of the internal malleolus torn off (Fig. 93). In the normal ankle-joint a mortice arrangement is present, the external malleolus being oblique, so that the joint is wider in front than behind, and the articular surfaces being of a similar shape, backward displacement is prevented.

When the external malleolus is displaced outwards, this arrangement is nullified, and the astragalus together with the rest of the foot is displaced backwards, and plantar-flexed by the action of the calf muscles (Fig. 94).

In the third variety with internal displacement (Fig. 95), the condition is caused by forcible inversion of the foot. Here the pressure is applied against the internal malleolus, which is broken off transversely at its junction with the shaft, and displaced inwards. The external malleolus is forcibly drawn inwards, and thus the shaft is bent outwards, and again gives way at its weakest point; but in this case the fragments tend to be bowed outwards instead of inwards. The backward displacement and plantar flexion will be similar to that of the last variety.

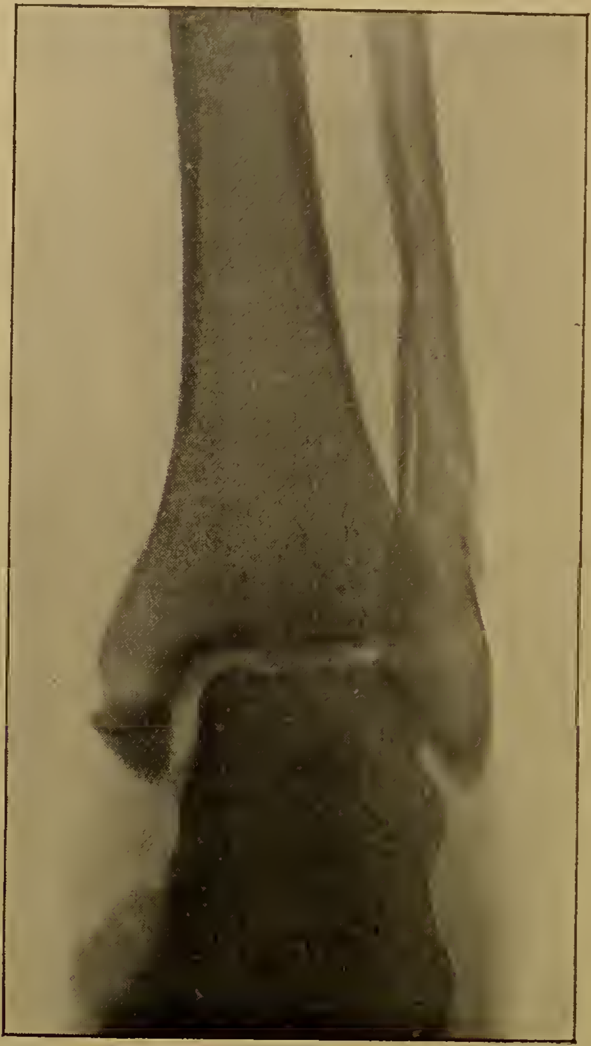

FIG. 95.—POTT'S FRACTURE: UNUSUAL FORM WITH INVERSION OF FOOT. (Mr. Fenwick's Case.)

The last type is one that has been fully described by

Dupuytren,[1] and is therefore usually known as "Dupuytren's fracture." It also is generally produced by eversion of the foot, but of a more severe nature than in the above varieties. In this case the chief injury is a complete rupture of the inferior tibio-fibular ligament. The fibula is fractured, often obliquely, the line of fracture passing through this ligament. At the same time either the tip of the internal malleolus is separated or the internal lateral ligament is torn, and the foot is thus widely displaced outwards (Fig. 96). The astragalus will be drawn backwards in the usual way, but at the same time it, together with the lower end of the fibula, will be drawn upwards. In some cases the external lateral ligament is also torn, when the astragalus will tend to pass

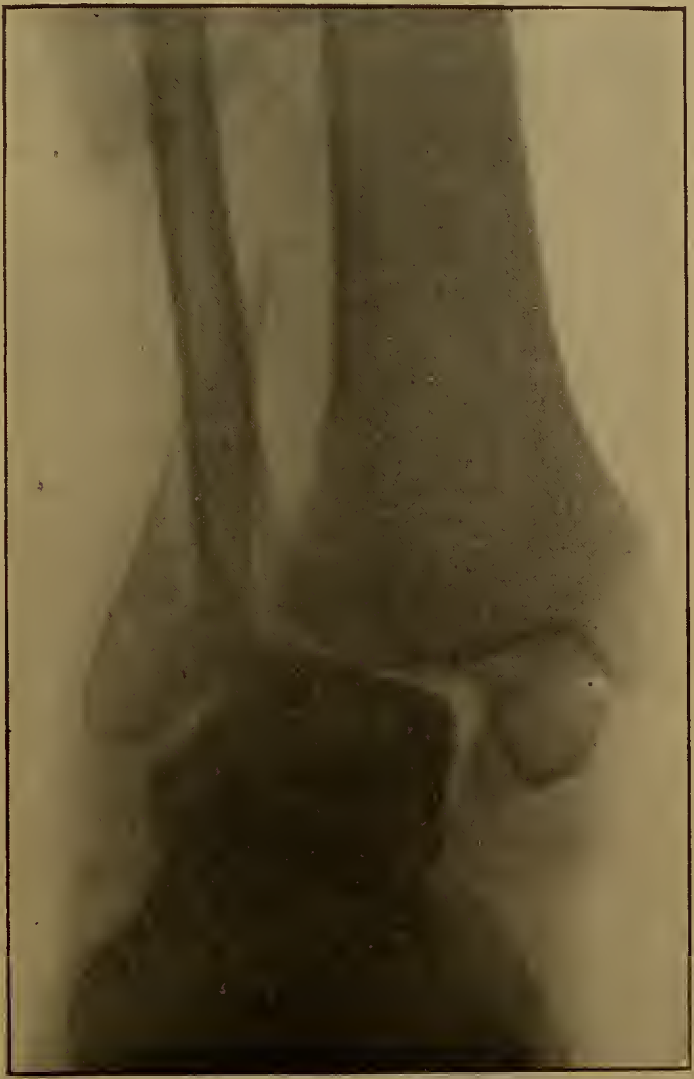

FIG. 96.—DUPUYTREN'S FRACTURE: INFERIOR TIBIO-FIBULAR LIGAMENT RUPTURED. (Mr. Eve's Case.)

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[1] *Leçons Orales*, 1834.

up between the lower ends of the tibia and fibula, the lower end of the latter bone not being carried up with the astragalus. Here, as in some extreme cases of the first and second types, the lateral displacement is so great that the lower end of the tibia is thrust through the skin, and the condition thus becomes compound.

Symptoms.—At the time of the accident the patient will fall to the ground, and generally will be unable to rise again without assistance. He will find that the foot cannot be put to the ground, and walking is impossible.

On examination the foot and ankle will be much swollen. In the common varieties the foot will be everted and displaced outwards, the heel will be more prominent owing to the backward displacement, and the foot will be plantar-flexed. Tenderness will be present over the internal malleolus or just below it, and about 1 inch above the external malleolus. Crepitus may be obtained in the latter position on gently everting the foot. The projection of the lower end of the tibia beneath the skin may be visible or palpable.

In the less common varieties the foot will be inverted; Dupuytren's type will be similar to the more common variety, but the deformity will be much more marked.

The lower end of the tibia may in some cases project through the skin, and be ingrained with dirt.

Treatment.—In all cases it will be best to overcome the deformity by manipulation under an anæsthetic, excepting, perhaps, in those in which it is very slight. In applying this manipulation the three deformities must always be kept in mind. The foot must be inverted, and backward displacement and plantar flexion overcome by extension upon the foot, first in a downward and then in a forward direction. The knee at the same time must be fully flexed so as to relax the calf muscles. It is sometimes advised that tenotomy of the tendo Achillis be performed, if deformity cannot be otherwise overcome, but provided that the knee be fully flexed the necessity for this will be extremely rare. When deformity has been reduced, the fragments must be maintained in position. Many forms of splint have been advocated, but the one known as Roughton's or Sharpe's splint is the simplest, and gives the best results. This should consist of a straight external splint passing down the outside of the leg, a straight piece lying along the outside of the foot, and a rectangular footpiece. It is not necessary, and is indeed unwise, to have this splint hollowed to receive the leg. When well padded, the flat sides are more serviceable.

The foot and leg are laid on this splint with the knee fully flexed (Fig. 97). The mere fact that the foot is lying upon its outer side will then usually cause sufficient inversion, but if more be required a pad may be placed under the foot. A strip of boric lint should be placed beneath the sole of the foot. The leg is now fixed to the splint by two straps passing over bands of cotton-wool. Care should be taken that the heel is in contact with the footpiece, and projects a little beyond the splint behind. A third strap is now applied in a figure of eight over the heel, and the foot pulled forward by it as in the figure.

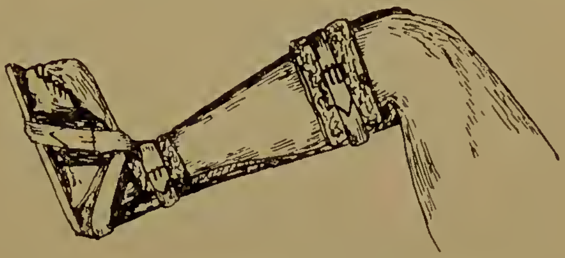

FIG. 97.—METHOD OF APPLYING SHARPE'S SPLINT.

With this splint the knee can be fully flexed, the leg lying on its outer side. Eversion is readily overcome by the position, plantar flexion by the footpiece of the splint, and backward displacement by the figure-of-eight strap.

Gentle massage is commenced on the second day, it being unnecessary to remove the splint. On the fourth to the seventh day the straps may be undone, and the splint slid out from under the leg. The fragments being supported by one hand, gentle passive movements of the ankle are commenced and continued daily.

At the end of three weeks, cases treated by this method will show as a rule firm union. There will be no pain, and the movements will be perfectly free. A divided plaster is now applied for a further week or ten days, and the patient allowed to walk, massage and passive movements being continued for another four to five weeks, when the patient is generally able to return to work.

Instead of using the above splint, the leg may be placed on a back splint, with a footpiece, which should reach only to the knee. A pad is placed beneath the heel, so that backward displacement is prevented, and not above, as in a fracture of the shaft. Care must be taken to see that the heel is in apposition with the footpiece, and the foot thus at a right angle. Two lateral splints are now applied, a pad, if necessary, being placed between the outer one and the outer side of the foot, so as to overcome eversion. The limb must be slung in a Bloxam's cradle, so as to flex the knee as much as possible. Massage should be commenced on the second day.

Dupuytren's splint should not be used, as the backward displacement and plantar flexion are not overcome, while Syme's splint, although overcoming the backward deformity, has no effect on the eversion or plantar flexion. Even when inversion is present, the best results will be obtained by the use of a Sharpe's splint after the deformity is reduced, for, provided that no external pad be used, there will be no tendency to cause inversion, and the other deformities, which are the more important, will be guarded against. It must be remembered that slight inversion causes but slight disability, whereas even a small amount of eversion leads to traumatic flat-foot and much resulting pain and weakness.

In Dupuytren's fracture the deformity must be fully overcome under an anæsthetic, but even here it tends to recur, the upward displacement of the astragalus being the most difficult to combat. It is best treated by putting up the foot in a position as fully inverted as possible, so that the inner side of the astragalus rests against the lower end of the tibia, the leg being at the same time as fully flexed at the knee as possible. This may be accomplished by applying a Sharpe's splint, with a large pad beneath the foot so as to fully invert it.

Owing to the tendency of this deformity to recur, passive movements should not be begun until the end of two and a half to three weeks, although massage may be commenced the day after reduction. For this reason, some limitation of movement of the ankle is very likely to result.

If the foot cannot be replaced by the above methods, an open operation should be performed. In the majority of cases an incision over the lower end of the fibula will be sufficient, the ends of the bones being then manipulated into position and fixed with plates. If this be insufficient, an incision should also be made over the internal malleolus, and this also secured in position. Massage and passive movements should be commenced in about seven days.

If compound, the parts must be thoroughly cleansed (see Compound Fractures), the deformity overcome, and, if necessary, the fragments fixed.

Both Bones.

This is one of the commonest types of fracture occurring in the leg. It may arise from indirect violence, such as falls upon the foot from a height, or from twists of the leg, or more commonly from direct violence, such as run-over accidents, kicks, or blows.

In the former case the fracture of each bone is usually oblique, and they take place at different levels (Fig. 98), the fracture of the tibia usually occurring at the junction of the lower and middle thirds, whilst that of the fibula is much higher up, generally about 2 to 3 inches below the head, these two portions being the weakest parts of

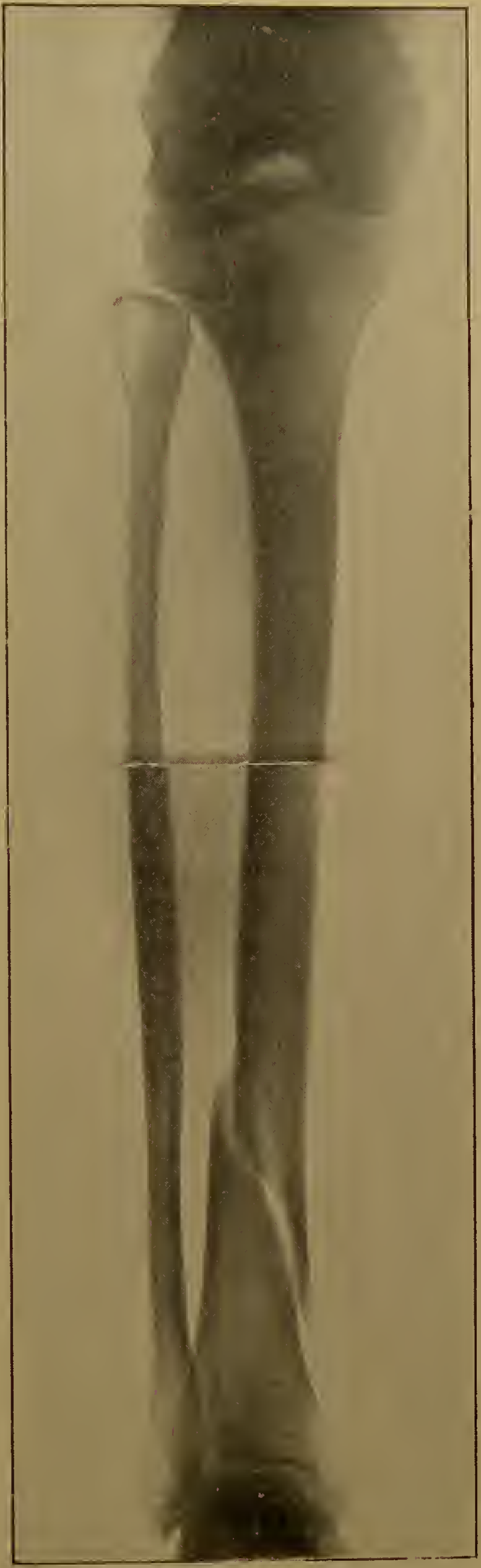

Fig. 98.—Fracture of Both Bones from Indirect Violence. (Mr. Eve's Case.)

the bones. As in cases of fracture of the tibia alone, the line of division of that bone is most commonly oblique from behind downwards and forwards.

The displacement is well marked, owing to the weight of the foot and the obliquity of the fracture. The lower fragment tends to drop backwards, and is then drawn up behind the upper, so that considerable shortening results. Owing to the backward tilting of the lower fragment, the lower end of the upper fragment projects forwards, and not uncommonly penetrates the skin, giving rise to a compound fracture. Alterations in the alignment of the two bones is also common.

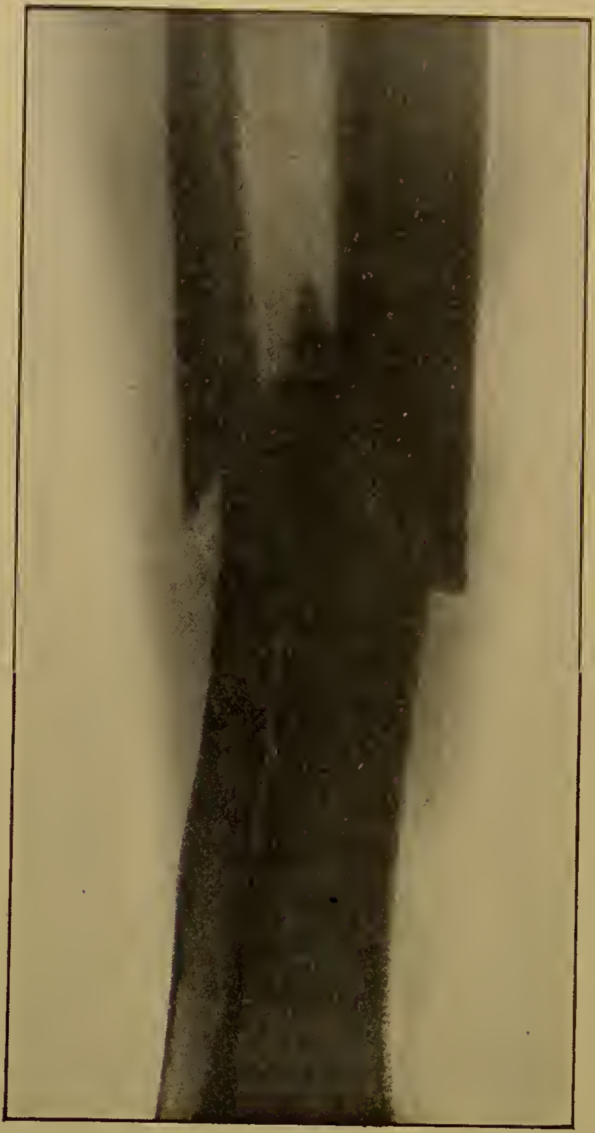

FIG. 99.—FRACTURE OF BOTH BONES FROM DIRECT VIOLENCE. (Mr. Furnivall's Case.)

When due to direct violence, the two fractures are usually at the same level, both being situated at the site of the trauma, so that fractures of the two bones may occur in the upper part of the leg, the middle, or just above the malleoli. Most commonly they are situated at about the middle (Fig. 99), as this part is most exposed to injury of this nature. The fracture tends to be transverse, but is often comminuted, sometimes to a marked degree, and the overlying tissues may be severely injured by the trauma, so that a compound fracture results. Owing to the line of the fracture, shortening is as a rule not nearly so marked, and the overlapping may indeed, even when comminution is present, be very slight. If the fracture be situated high up, the lower part of the limb may be everted by its own weight. The fragments at the site of fracture often tend to be drawn in towards one another, so that cross-union may result.

Symptoms.—The limb will be completely useless. Attempts to lift it are followed by dropping of the lower portion, and cause much pain. Bruising and swelling will vary with the nature of the violence, being more marked when this is direct. The lower fragments will be freely movable, especially from side to side, these movements being accompanied by pain and crepitus. If the fracture be oblique, the lower end of the upper fragment may be felt, or even seen, beneath the skin, or may have perforated this structure. Shortening will also be present here. The relationships around the ankle will be unaltered, and thus prevent confusion with a Pott's fracture. The position of the fracture, the presence of comminution, and the amount of displacement, will be best estimated with a radiograph.

Treatment.—If the displacement be but slight, the limb should be supported in back and side splints in a manner similar to that adopted for fractures of the tibia alone. Special care must, however, be taken that there be no undue pressure upon the leg, especially over the bruised areas, and any blisters must be carefully punctured and dressed with boric lint. These areas, especially in old or alcoholic men, are very prone to become infected and to slough. The area above the heel, where the limb rests upon the pad, must also be carefully dusted and watched, as pressure sores are in these patients very likely to form here. The leg must be well flexed and supported from a cradle to overcome contraction of the calf muscles. The after-treatment will be similar to that of a fractured tibia alone, but union sufficiently firm to permit the application of a plaster is likely to require more than three weeks. This, in fact, is one of the places in which delayed union is more likely to occur, but is certainly less frequent with the routine use of massage.

In some cases, especially those due to direct violence, it will be found that shortening is not entirely overcome, even when the knee is well flexed and the muscles relaxed by massage. In these cases it is best to apply some form of extension. This may be carried out by using a back splint the footpiece of which is made to slide up and down.

When the foot is firmly bandaged to this, a certain amount of extension—about 4 to 5 pounds—may be applied. By this means massage of the muscles is not interfered with, and thus the spasm may be overcome.

This method of extension may be insufficient to overcome deformity. This is then probably due to the interposition of some surrounding tissue, such as muscle or tendon, between the fragments. An open operation should then be performed; otherwise non-union is almost certain to occur. An incision is made over the site of the fracture in the tibia, and if necessary a second one over the fracture in the fibula. The ends of the fragments are cleared, the fractured surfaces exposed, freshened, and any adventitious substance between them removed. The fragments are now manipulated into position, fixed if necessary by Peters' forceps, drilled, and then firmly united with silver wire if the fracture be oblique, or with screws and plates if transverse, the skin being sutured without drainage.

The after-treatment will be similar to that of a simple fracture with back and side splints.

Massage and passive movements are commenced on the tenth day, and the splints not removed until the end of four to six weeks, when they are replaced by a divided plaster and the patient allowed to walk. The plaster must not be discarded for a further month or six weeks, during which time daily massage and passive movements are continued. Compound fractures will be treated on the lines already laid down (see p. 48). Aluminium splints (p. 24) will often be useful here, the limb being suspended by them from a Bloxam's cradle.

Prognosis.

Fractures through the tuberosities of the tibia will, owing to the implication of the joint, always be followed by a period of prolonged treatment before active use is regained. The length of this will, of course, be extremely variable. If one tuberosity be alone separated, and the displacement be but slight, the patient may be able to return to hard work at the end of three months. In other cases it will be much longer, and if the displacement be considerable, severe arthritic changes may result, in spite of open operation and early massage and passive movements, so that the joint may never return to its normal condition, limitation of movement and pain preventing the patient from returning to heavy employment.

The worst results are seen where not only is the bone severely fractured, but the ligaments are torn. In this case, in spite of the most careful treatment, weakness of the joint is likely to result, and may necessitate the constant wearing of some supporting apparatus. Fractures of the spine of the tibia are so rare that it is difficult to estimate the prognosis, but from reported cases it seems that the symptoms will resemble those of a foreign body within the joint, and until an open operation be undertaken the joint will never be free from attacks of locking and subsequent synovitis. The prognosis after operation will depend very largely upon the interval that has elapsed before this is done, but probably a year at least will pass before the joint can be used to any degree, and some limitation of movement or weakness is likely to persist much beyond this.

The prognosis of separation of the epiphysis has already been dealt with.

Fractures of the shaft of one bone alone are usually followed by good results in children. Union is generally firm, and the child able to run about, with no symptoms, at the end of six to seven weeks. In adults, even in the most favourable cases, the limb will probably not be fully fit for use until the expiration of two to three months from the time of injury, and pain is likely to persist for some weeks or months longer.

In compensation cases, six weeks will usually be sufficient to allow for a simple fracture of the fibula, and three to four months for one of the tibia.

If compound, the period of convalescence will be much prolonged.

If both bones be fractured the results will not be so good. Not only is more deformity likely to result, but firm union will take longer to occur. These cases may be compound, and sepsis result, or union may be delayed or prevented by the interposition of surrounding structures, and thus open operation will be called for. In simple cases with but little deformity, union may be firm, and the patient free from all symptoms, in three months.

If compound, and sepsis result, it may be six months before the wound is closed, and eighteen months to two years before complete use is restored. In fact, in many such cases the patient is unable to return to his work at all.

Similar results may follow in cases where the deformity is great, but the prognosis will be greatly improved with open operation followed by massage and passive movements.

Fractures around the ankle-joint are very common, and are often followed by serious results. In many cases with slight displacement, if treated by early massage and passive movements, the patient has free movement, and is able to walk with the support of a divided plaster at the end of three weeks; but if these cases be followed up, it is surprising how many relapse, largely, it is true, from their own lack of care in following up the after-treatment. If this be persevered with they may be absolutely free from symptoms at the end of two months.

With much displacement the results are not nearly so good. Even slight eversion of the foot is followed by great weakness and pain from a resulting flat-foot, while movements are likely to become limited by a subsequent arthritis, which is often slowly progressive, so that many cases of the more severe variety are followed by permanent disability. Warren's[1] statistics on these cases are very valuable from this point of view. Of thirty-two cases of this nature, twenty-one (*i.e.*, 64 per cent.) showed good results, but many of these only after eighteen to twenty-four months after the accident. At the end of two to three months one half were good, the other half only fair. Twelve cases were seen at the end of eighteen to twenty-four months; of these, ten were good or very good, one bad, and one fair. It must be remembered that these must be regarded as exceptionally good results, all these patients having had the benefit of prolonged after-treatment in the form of massage, passive movements, and exercises.

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[1] *Lancet*, July 17, 1909, p. 139.

Of the cases with inversion, it is noteworthy that there were three, all of which did well, showing that inversion gives much less serious results than eversion.

Gibbons[1] examined twenty-three cases of fractures of the tibia and fibula in various positions, and found that twelve were incapacitated for periods exceeding one year, while among the others were several in which the final results were not yet known. Very few of these, however, were treated by early massage.

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[1] *Brit. Med. Journ.*, February 5, 1910, p. 314

CHAPTER XVI

FRACTURES OF THE TARSAL AND METATARSAL BONES

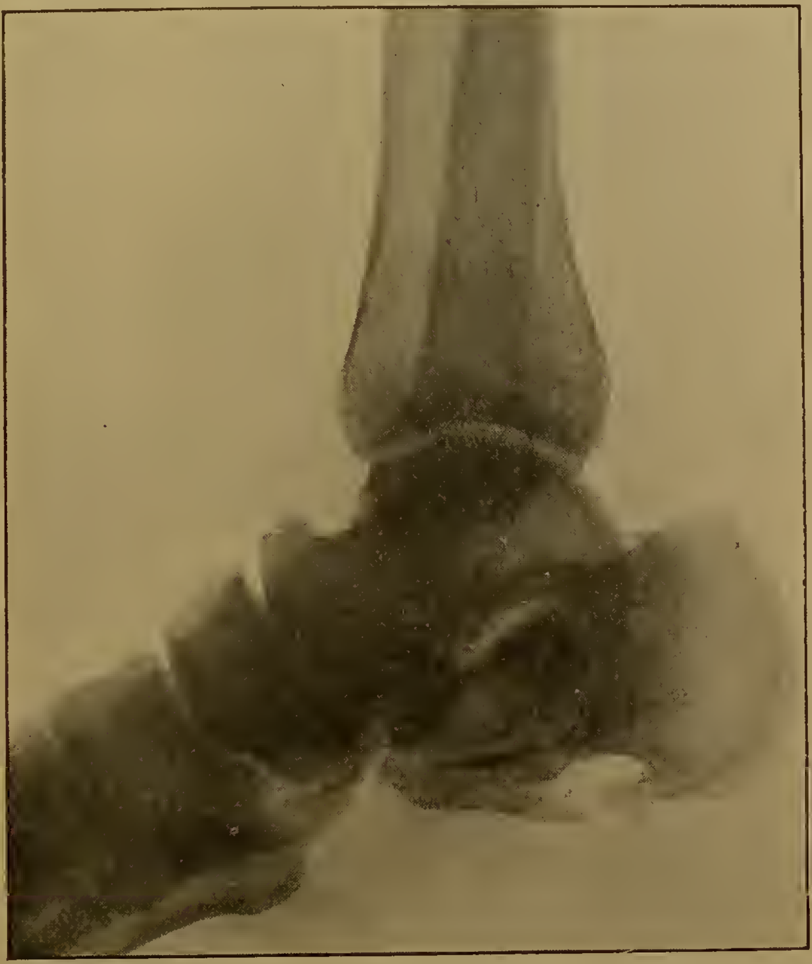
FROM severe direct violence, any or several of the bones of the tarsus and metatarsus may be fractured. Of the individual bones of the tarsus, however, the only ones frequently fractured and likely to be associated with much deformity are the astragalus and the os calcis. Fractures of the other bones of the tarsus may be comminuted, and are often compound, and in the majority of cases several bones are injured.

Os Calcis.—Fractures of this bone are generally due to falls from a height. A common accident is that where a decorator overreaches himself and steps off his plank, falling a distance of 3 to 4 yards, and striking the ground with the soles of his feet. In this case the tibia and astragalus are driven down on to the os calcis; the arch of the foot is thereby flattened, and a comminuted fracture results (Fig. 100). A similar condition may be brought about by the passage of heavy weights over the foot.

The posterior part of the os calcis is drawn up by the tendo Achillis, and the arch completely flattened. It may be associated with a fracture of the astragalus. In either case the fragments are nearly always impacted, so that there may be difficulty in reduction.

More rarely a fracture may be produced by muscular violence. In this case there is a sudden forcible contraction of the gastrocnemius and soleus, which tears off a strip from the upper-surface of the os calcis. The fracture is then transverse, but is rarely complete, the anterior end remaining attached, whilst the posterior is tilted up for a considerable distance (Fig. 101), a wide gap being left below.

Symptoms.—After the accident the patient will be unable to walk or to stand on the affected foot, where there will be much pain. Swelling of the part will very rapidly make its appearance, so that an accurate diagnosis may be difficult or impossible. If this is not very marked, flattening of the foot may be noticeable, while on the outer side of the foot thickening or irregularity of the os calcis may be apparent. If the fracture be unimpacted, crepitus may be obtained, especially on lateral movements of the anterior part of the foot. Generally, however, a diagnosis is difficult without a radiograph. This will show partial or complete abolition of the arch of the foot, and a varying amount of irregularity of the under-surface of the os calcis.



100.—FRACTURE OF OS CALCIS, DUE TO A FALL FROM A HEIGHT. (Mr. Dean's Case.)

The flattening of the arch is well shown.

When a portion of the posterior part is torn up by the tendo Achillis, there will be pain and swelling over the back of the heel, with loss of the power of plantar flexion, attempts at this being accompanied by pain. The separated portion of bone may be felt projecting upwards, with a deep gap below, between it and the rest of the bone.

Treatment.—There will be a great tendency for a certain amount of traumatic flat-foot, with disability, to persist. Cotton and Wilson[1] estimate, on an experience of ninety cases, that permanent disability follows in much more than one half of the cases. Attempts must therefore be made to overcome the deformity and to restore again the arch of the foot. The main preventative to this is the tendo Achillis, which must therefore be fully relaxed. An anæsthetic should always be given, and

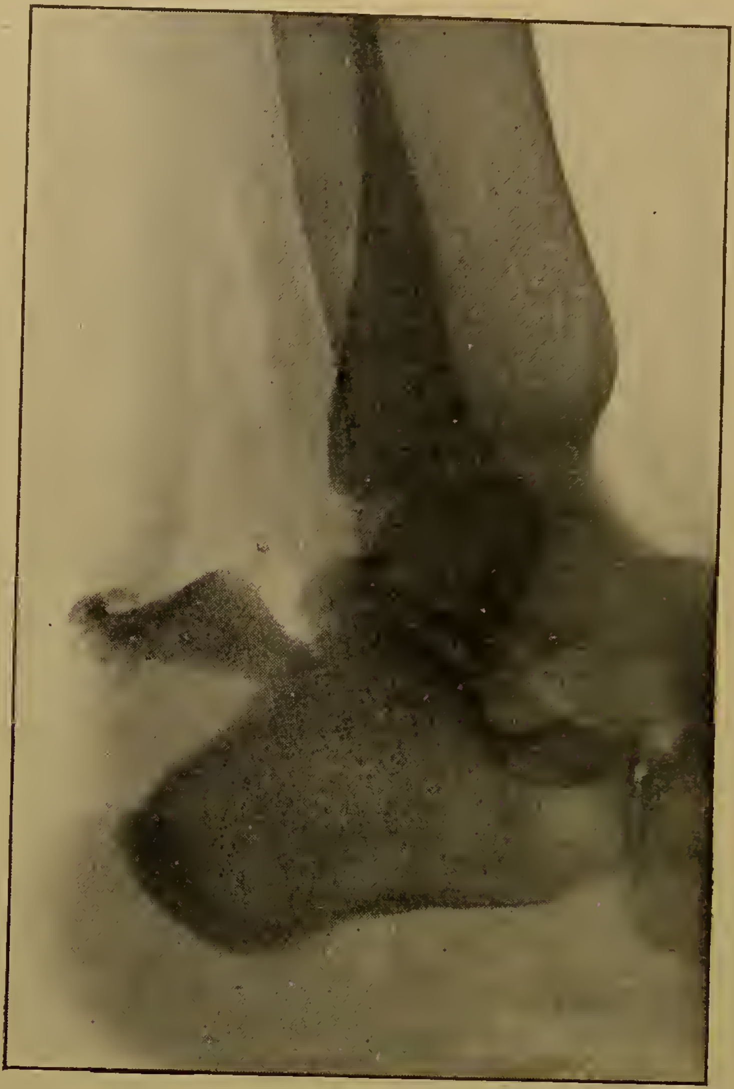


FIG. 101.—HORIZONTAL FRACTURE OF OS CALCIS, DUE TO MUSCULAR VIOLENCE. (Mr. Hutchinson's Case.)

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[1] *Boston Med. and Surg. Journ.*, October 29, 1908, p. 559.

attempts made to overcome the deformity by forcibly plantar-flexing the foot. At the same time the posterior part of the os calcis must be firmly held down, the knee being fully flexed to overcome any spasm of the tendo Achillis. When deformity is remedied, a divided plaster should be applied, with the foot and knee in this position. It is very useful to place a well-arched Whitman's steel brace, such as is used for flat-foot, beneath the arch, the bones of the foot being moulded over this. Passive movements and massage may be commenced in a week. The plaster may be removed at the end of three to four weeks, but the patient should not be allowed to walk until the end of six to eight weeks, and should then always wear a steel brace in his boot, or a valgus instrument, until the end of four months. Exercises aiming at increasing the arch of the foot should be carried out daily. Cotton and Wilson advise that impaction be broken down by forcibly flexing the toes when the posterior part of the os calcis is held down. In some cases it may be difficult to hold down this posterior part sufficiently firmly. They then advise that a small incision be made on either side in front of the tendo Achillis, and a steel bar passed through over the top of the os calcis, whereby this may be held down. After disimpaction the fragments are reimpacted either by pressure or by blows with a mallet upon the protected outer side of the foot. Such forcible methods are, however, rarely necessary if the steps advised above be carried out. With them also it will be but seldom necessary to divide the tendo Achillis to prevent flattening of the arch.

If a flake be torn off the posterior part, a vertical incision should be made or a flap turned down, the foot fully plantar-flexed, and the fragment firmly screwed into position. The foot is then put up in a divided plaster in a position of full plantar flexion to relax the tendo Achillis, the knee being flexed at the same time. Massage and passive movements may be commenced as soon as the wounds have healed, the plaster being left off at the end of three weeks.

If compound, the wound should be thoroughly cleansed, all loose fragments of bone removed, and the foot placed on a back splint, with a steel brace beneath the arch. Massage and passive movements are begun as soon as the wound has healed.

Astragalus.—Fractures of this bone are much more rare than those of the os calcis. Like them, they are generally due to falls upon the foot from a height. Such a fracture may be coupled with a partial or complete dislocation of the bone, or with a fracture of the os calcis. The fracture may be simple, when it is nearly vertical and passes through the neck, or comminuted, when the body is mainly affected. Either the astragalo-scaphoid or the ankle joint may be involved.

Symptoms.—The symptoms will be less marked than in the case of a fracture of the os calcis, and some of the cases are mistaken for a sprain; but pain upon standing may be very marked, and swelling soon appears in front of the ankle-joint. Crepitus may be obtained, especially on making lateral movements of the foot. A radiograph may show very little if there be no displacement, but often the head of the astragalus may be seen to be considerably separated from the posterior part.

Treatment.—If there be no displacement, the foot should be placed on a Sharpe's splint and evaporating lotions applied until all swelling has subsided. Massage should then be commenced, a divided plaster being fitted to hold the fragments in position. Passive movements are begun in two weeks. Such cases will generally be able to walk without support in two or three months.

If there be much displacement, it will generally be possible to overcome this, for as a rule the anterior part is carried forward with the rest of the foot. Under an anæsthetic the foot may then be pulled back into position, and the head of the bone will accompany it. Treatment should then be continued as in the first type of case. If the bone be comminuted, the parts should be supported, massage commenced at once, and passive movements in about a week. Ankylosis of the ankle will thereby be lessened.

Fractures of the other bones of the tarsus are due to direct violence, and are accompanied by but little deformity. Their symptoms and treatment will be similar to those of fractures of the metatarsals.

Metatarsals.—Fractures here are nearly always due to direct violence, generally from run-over accidents or from the foot being stepped upon by a horse. The first and fifth bones, from their more exposed position, are most often injured. In the case of the inner bones, two or three may be simultaneously broken. Either the shaft or the base is most commonly affected. The fracture may be compound.

Symptoms.—The foot will be swollen and painful, the pain being increased by all attempts to walk or stand. Crepitus may be obtained by movements of the proximal ends of the bones one at a time. Some cases of fracture of the bases may be only recognizable by a radiograph.

Treatment.—The patient should be kept in bed, with evaporating lotions to the part, until all swelling has disappeared. Massage may then be commenced. At the end of a week or ten days he may be allowed to walk, the foot being supported in a thin divided plaster, which is removed daily for massage and passive movements. At the end of three weeks all support may be dispensed with.

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